ANNALS
OF
OTOLOGY, RHINOLOGY
AND
LARYNGOLOGY

INCORPORATING THE INDEX OF OTOLARYNGOLOGY.

VOL. XXXI. MARCH, 1922. No. 1

I.

THE PROBLEM OF MIDDLE EAR MECHANICS.

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The paper has been divided into three chapters. This has been done to make the article less cumbersome and to do away with any idea of a monographic treatise. The bibliography has been reduced to a minimum of the more important articles cited.

The subject matter of the first chapter includes the following topics:

1. The interpretation of relation of structure and function and the importance of comparative study.
2. A brief statement of the structural complex of the middle ear in anurans, birds and mammals.
3. A description of the passive traction system of elastic ligaments and their relation to middle ear musculature and displacements of the sound transmission system.
4. A statement of the theory-group, which may be termed the theory of the indirect activation of the end organ illustrated by the Wrightson theory.

5. The proposal of seven leading questions which together with the answers constitute serious objections to the theory of indirect activation, in particular to the Wrightson theory.

Chapter II of this article will take up:

1. A summary of the seven questions to make Chapter I overlap Chapter II.

2. A statement of wherein the theory of direct activation opposes all theories of indirect activation.

3. The mechanics of the diaphragm-rod theory of sound transmission.

4. The relation of a complicated apparatus to the damping effect on sound transmission.

5. An interpretation of middle ear mechanics of anurans, birds and mammals dependent on a middle ear function apart from that of sound transmission.

Chapter III will consist in:

1. A summary of the subject matter in Chapter II in the form of answers to the questions asked in this chapter.

2. Interpretation of air and bone transmission of sound.

3. A consideration of wherein the diaphragm-rod theory of direct activation lends itself to an explanation of—

a. The Weber phenomenon.

b. The Schwabach test.

c. The Gelle observation.

d. The Rinne-negative group.

e. The instances of excellent hearing with loss of drum membrane and ossicles.

f. The condition of paracousis Willisi.

g. The loss of hearing in otosclerosis.

The writer wishes to extend his thanks for helpful suggestions and assistance to many colleagues, in particular to Father de Laak, Father Gruender and Mr. Carl Miller of St. Louis University; to Prof. A. L. Foley and Prof. W. J. Moenkhaus of Indiana University and to Dr. F. B. Jewett of the Research Department of the Western Electric Co. of New York City.

CHAPTER I.

It is the writer's purpose to bring the general aspects of this very complicated problem into a reasonably accessible and readable form. The physical, anatomic and physiologic ma-

terial presented is designed to place the reader in a position to judge for himself whether or not the present accepted explanations fit the facts. The problem itself merits and demands the attention of clinical observers.

The terms "structural adaptation" and "functional adaptation" are rather loosely employed to cover certain deficiencies and errors in observation and interpretation. When a given region displays an anatomy which accounts satisfactorily for the functional results, we are wont to speak of it as "structurally adapted." When the physiologic results are not distinctly correlated with the structural complex, we regard the organ as "physiologically adapted." It may be that these terms are often regarded as interpretations of facts when they represent for the most part a conception of the limitations of knowledge. Structure and function, like the chick and the egg, arise synchronously, and are difficult to separate in one celled forms. A structure does not appear because of a physiologic demand nor is a result in function necessarily associated with the anatomic character of the organ.

The correlation of structure and function is one of the most difficult problems in natural science and involves asking the question "Why?" In answering this question both anatomist and physiologist are driven back to a catch-all system of terms comprising a group of phenomena spoken of as "vital manifestations." In other words, the answer is: "We don't know." However, in approaching the boundary line of "vital manifestations," the terms "structural adaptation" and "functional adaptation" are coined, giving the impression that they really explain something. As a matter of fact, these terms are admissions that cause and effect closely resemble each other. The two terms may be used almost interchangeably in an explanation. Structural factors are naturally more readily associated with adaptive results than are functional requirements accounted for by structural changes. In other words, it is more logical to assume that the camel wandered out on the desert to escape its enemies because of its peculiarities in structure than to argue it wandered out on the desert to escape its enemies and became structurally modified. The desert adaptation is therefore a cause or a result? It is more likely a cause, although considering it as a result appears to offer an

"explanation" which is satisfactory to the majority of people.

The translation of a structure which results in a modified function or the apparent development of a new organ to anticipate a function is one of the most baffling of all developmental problems. Yet this much we know in a reasonably definite way. The entire vertebrate anatomy is built up on a more or less fixed plan. Every form of animal shows at least two types of organs; first, an active functional system of organs which may be definitely correlated as useful and connected with the survival of the form; and second, a less active, or perhaps nonfunctional system of organs which are not definitely useful and perhaps not definitely correlated with survival. This latter class of organs is made up of at least two varieties of structures. First, organs which are rudimentary in character but which at one time functioned as organs of the first variety. These are of historic interest and their former function is more or less easily determined because of the structural history (phylogeny). The second variety of nonuseful organs comprises a limited class which are perhaps "forerunners," not dependent on past or present requirements. These are undoubtedly related to the possibilities of the future in structural variations upon which "sport forms" may be derived. This last named class of structures would be indeed difficult to list in the human being because we have no knowledge of the possibilities in his future modifications.

If we disregard structural variations of doubtful future importance it follows that the present function of any system of organs is in part dependent on its ancestral requirements. Just so the structure of any system is related to the anatomic pattern upon which the vertebrate is constructed. For example, the olfactory apparatus is in no direct way associated with the function of the respiratory tract. It preserves its ancestral relation to the digestive tract and the genital system as first found in the fishes. With the structural modification of an aquatic form into a terrestrial vertebrate, the olfactory area became folded into the new respiratory passage concomitant with lung respiration. It is "functionally adapted" to preserve its old manner of receiving and transmitting impulses, and the requirement of a watery medium is maintained in the development of a new glandular apparatus. This preserva-

tion of a definite type of ancestral organ is also paralleled in the survival of ancestral functions for which there is neither a direct anatomic nor a physiologic explanation. The "ear-cough reflex" elicited by tickling the drum membrane or brought about through middle ear disease, may not be explained except as a survival of a respiratory reflex mechanism present in the fishes and amphibians and perhaps of no great physiologic value in man. A persistence of phylogenetic structure and phylogenetic function must therefore be carefully borne in mind. Both structure and function may be found in a system without reference to its apparent office at the present time. The older requirements may be entirely overlooked because the "adaptations" appear to be complete and the present relation of structure to function too plainly obvious. Facts are one thing and the interpretation of facts is dependent on the personal equation and limitations in the observer. The reader will please bear this last sentence in mind in considering the subject matter to be presented and the deductions which are to follow.

A consideration of middle ear mechanics has usually been directly associated with the function of the inner ear. The middle ear region itself has, however, a complicated anatomic and physiologic hsitory. This history must be included in the determination of its function apart from the significance of a relation to acuity in hearing or to the mechanics of the inner ear itself. It is obvious therefore that the comparative anatomy and physiology must be carefully considered before we may separate that which is of phylogenetic importance from that which has a definite relation to newer structures and functions. In other words, a correlation of the comparative anatomy and physiology must be established before we can properly evaluate the mechanics of the middle ear itself as opposed to that associated with the inner ear and end organ.

It will be recalled that the middle ear, tuba and drum membrane arise in terrestrial anurans. The relation of structure to function is at the present time under investigation by a number of writers. The mechanics of the frog's ear are apparently complicated by a series of factors:

First. By the respiratory function of the middle ear region as determined by its blood supply through the pulmocutaneous

vessels tributary to the left auricle. It is also demonstrated by the observation of actual displacements of the surface drum membrane which occur during respiration.

Second. In the development of a fenestra cochleæ (round window) which is not in relation to the tympanic cavity but is located at the base of the skull and applied to a lymph sinus.

Third. In the wide dehiscence which exists in the otic capsule on its subdural aspect.

Fourth. In a peculiar regulator muscle which arises from the suprascapula and attaches to a skeletal element (operculum) functionally interposed between the medial end of the sound transmitting apparatus (columella) and the perilymph of the vestibule.

And finally, in a wide open tuba auditiva which connects the cavum tympani to the mouth cavity. It appears as soon as the metamorphosis of an aquatic form into one of the terrestrial habit occurs (tadpole into frog) certain changes take place in the inner ear apparatus, namely, the development of a second analyzing area for the appreciation of sound vibration. This represents a new functional requirement concomitant with new physical requirements because the watery medium is not physically constituted for the natural origin of sound itself.

The old type of inner ear, with the progressive development of semicircular canals and its undoubted reception of noises and pressure appreciation found in the fishes, is developed in the direction of sound appreciation in the tadpole before it leaves the water. The region of the first branchial pocket is modified into a tuba, middle ear and drum membrane. Further, a cartilaginous rod is interposed between the drum membrane and inner ear to furnish a transmission system for sound vibrations to the perilymph (fenestra vestibuli).

Apparently another requirement is met in the origin of the second window (fenestra cochleæ). This window does not develop in relation to the tympanic cavity at all, but seems to allow for a mass displacement in the perilymph due to the apposition of movable skeletal elements (operculum and columella) to the liquid of the inner ear. The operculum is functionally interposed between the columella and the perilymph and has a muscle attached to it which arises from the supra-

scapula. The operculum is provided with a stout elastic ligament which undergoes stretching during the muscle pull. The ligament returns the skeletal element to a position of rest on relaxation of this muscle. The drum membrane displacements brought about through active injection of air into the tympanic cavity during breathing are geared down in the columellar system. For this reason, movements at the footplate are markedly reduced in proportion to drum membrane displacement. The action of the opercular muscle appears to inhibit marked inward thrusts of the columellar system. It therefore probably takes care of excess pressure propagation from the drum membrane or prevents an excessive mass displacement in the perilymph proper. It is interesting to note that in higher forms with later functional tubal closure, the wide dehiscence in the otic capsule adjacent to the subdural space becomes pronouncedly reduced—practically to a aqueductus vestibuli. The round window in higher forms, with certain exceptions, rotates to face the tympanic cavity. In any event, the perilymph pressure in the amphibians is directly related to intracranial pressure and to blood pressure. Displacement factors in the perilymph are therefore necessarily spread over a relatively enormous area.

It is necessary to eliminate the reptile family from this brief phylogenetic survey because the forms, such as snake, lizard and turtle, are extremely variable, and because our information on their middle ear mechanism is not well understood. The reactions of the inner ear to the mechanic factors in sound transmission, particularly in comparing the aquatic turtle forms with terrestrial varieties, are extremely interesting but may not be taken up in this paper.

Birds, on the contrary, show great uniformity in the structure of the middle ear apparatus and represent a form which the writer has investigated somewhat extensively. The conclusions on the middle ear mechanics may be stated in very general terms after certain points of similarity and dissimilarity to those of the mammal have been discussed.

While the tympanic cavity and transmission system are very different in the bird to that in the mammal, there can be little question regarding the acuity in hearing. The one prominent feature in the bird's middle ear which points to a similar func-

tion to that in mammals is this: The gross drum membrane displacements do not give rise to correspondingly marked movements at the perilymphatic end of the sound transmitting apparatus—at the fenestra vestibuli. It is a matter of fundamental importance that some comparison be made of this region in birds and mammals, because of a marked similarity in function and an equally pronounced dissimilarity in structure. The bird, like the mammal, has a functional separation of the middle ear region from the mouth or nasopharynx in a tuba auditiva which is usually closed. The general differences may be discussed under several headings:

First: The tubæ of birds open by a small, short, common duct into a recess in the roof of the mouth which is bordered by palatal folds and muscles. The animal may be said to have a sort of functional cleft palate which appears to shear off the tubal recess and respiratory area of the nose during swallowing. This may in part account for the curious manner of drinking. The stout walled common tubal duct occupies a foramen between the sphenoid and occipital bones. It immediately forks into two bony tubæ auditivæ which lead into the right or left tympanic cavities. A movable cartilage tube or the direct influence on the tubal wall, as described in the raising of the soft palate in the mammal, does not occur. The tubal duct, notably in the goose, is provided with a stout involuntary musculature which appears to function in part as a sphincter. Definite elastic ligaments, which again in the goose are largely smooth muscle, are prolonged up the tubæ from the region of the tubal duct. The function of this apparently skeletal involuntary muscle is not known at the present time. The opening of the tubal duct is therefore not comparable to the opening of the tuba in the mammal. It may be said, however, that the recess in the mouth bears a somewhat suggestive comparison to the described function of a soft palate.

Second: The pneumatization of the bird's skull through the tubæ and middle ear is especially extensive. This results in an obvious lightening of the skull, which might immediately suggest itself as a structural adaptation. The causal factor in the air sinus development is probably quite a remote one and must be mentioned if but briefly. The origin of the air sinuses is probably due to the same sort of factor which occa-

sions the pneumatization of other bones in the bird associated with respiratory function and with the curious manner of rebreathing the air through the lungs. It may be well to consider this point, because the bird's accessory sinus system lends itself well to a comparison with the respiratory middle ear in frogs. The air sinus system may therefore represent, more or less, an earmark of recapitulation in the mammal, appearing late and of feeble respiratory nature. It is not proper to dismiss the cause of air sinuses with the lightening of the skull result on the basis that a poor explanation is better than none. It is the writer's opinion that the persistence of an ethmoidal labyrinth is of a distinct mechanical disadvantage in the primate. It appears that with ventral rotation of the eyes came a medial displacement of the orbital walls until finally the two medial walls became parallel or roughly so. However, the marked divergence of the orbital axis does not allow for the coordinated eye movement in the primate, in whom parallelism arises because of a fovea and a fusion center. The result is that parallelism is only attained by muscular action, and accounts for the lateral shifting of each eye during sleep, after death, or even in the far away look of inattention.[32]

If we regard the air sinuses as phylogenetic remnants, the enormous variation in development and the readiness of their infection from the pathologic nose of the modern civilized state at once becomes more easily understood. Not only is the air sinus system connected with the tuba and middle ear of birds much better developed, but the right and left systems are confluent across the middle line through absorption of bony partitions. These partitions are absorbed before the hatching of the chick—i. e., before the spaces are ever exposed to air. The responsibility for the origin of these spaces must therefore undoubtedly be due to at least two factors: one of ancestral character, because of the structural pattern; and the other, as an adjustment to the replacement of excess bone development dependent on the thrusts and stresses imposed through weight and muscular traction. Apart from the mastoid region, which displays marked reaction to the pull of the M. sternomastoideus, the air sinus region of the mammal is curiously devoid of stout muscular attachments. There is

a suggestion that air sinuses are a result, not a cause of the bone absorption.

The enormous surface area of the large confluent air sinus system, when associated with the minute single tube-duct orifice in birds, permits the establishment of a mechanical factor connected with the drum membrane region in two ways:

First. The probability of air absorption from this large surface creating a negative pressure on the drum membrane.

Second. The great amount of air contained and the minute tubal orifice expose the bird's middle ear region, particularly the drum membrane, to large barometric fluctuations. The very fact that the amount of air contained and the amount of surface do not bear a definite relation to the size of the drum membrane makes the problem an interesting one. This is particularly true in comparing the mechanics of this region in birds and mammals. It will at least be admitted that the bird's drum membrane is exposed both through habit and structure to greater possibilities in barometric fluctuations than in the mammal. This point will be elaborated in greater detail later when certain other structural features have been discussed and their correlation with the bird's drum membrane mechanics considered.

Third. The drum membrane in birds is relatively larger than in mammals and more delicate in construction, particularly in its anterior portion. It is also more movable as a whole than that of the mammal. This mobility in the drum membrane, however, does not arise on account of its attachment. While an annulus tympanicus is wanting, the surrounding bony area is thoroughly fixed except in front, where the drum membrane abuts on the quadratum. This quadrate bone in the birds, for the benefit of those whose memory of comparative anatomy may be somewhat hazy, is intermediate between the mandible and the head. It also participates in a swinging motion, with movements of the upper bill, particularly in some birds like the parrot. This bone is either suppressed in passing from bird to mammal or is transformed, together with the articulare, into the malleus-incus, which may account for the curious relation of the processus anterius mallei to the fissura petrotympanica. The definite arrangements of the circular and radial drum membrane fibers, re-

garded as dampers or as inhibitors to periodic drum membrane vibrations by the Helmholtz school, are not found definitely in birds. Neither is the umbo of the mammal, regarded as a sort of inverted megaphone, and held as extremely important by some in the catchment of sound vibrations, present. The bird's drum membrane is convexed outward—roughly at right angles to the axis of the external auditory canal. The drum membrane in birds is capable of much greater inward and outward excursion than is that of the mammal with its very restricted movements in this respect. On negative pressure, the drum may come to apply its anterior surface to the wall of the external canal. On positive pressure, the same segment may flatten against the medial wall of the tympanic cavity. It will appear from this alone that the fixity, tension, structure and position of the mammalian drum membrane in terms of sound catchment efficiency may be strongly questioned when compared to the indisputable evidences, at least end result evidences, of the highly efficient membrane in birds. It may be possible that too much stress is placed on a plausible interpretation rather than on one which will harmonize with the fundamental facts and relations.

Fourth: Unlike the mammal, the bird possesses but one voluntary muscle attached to drum membrane and sound transmitting apparatus. This muscle was first described as a laxator of the drum, but later investigators seemed to prove it to be a tensor. It is accordingly named the M. tensor tympani, which perhaps is unfortunate, as will be developed later. The muscle arises outside the skull near the occipital condyle. It passes through a foramen into the territory of the external auditory canal to insert by tendinous fibers into the dorsal inferior drum quadrant and the lateral cartilage apparatus of the sound transmitting system (extracolumella). The muscle function has been carefully examined by Breuer,[7] who describes the action as a drum tensor and also one which displaces the columellar apparatus out of the oval window and thereby decreases intralabyrinthine pressure. He calls attention to an important point: that if this single muscle functions in a manner which replaces the M. tensor tympani and M. stapedius in the mammal, then the two latter muscles cannot be regarded as opponents but as synergists. The writer has

called attention to certain unconsidered factors in relation to this peculiar muscle, and the reader is referred to another article[33] for the details of description or function of the elastic ligament system associated with the drum membrane and sound transmitting apparatus in birds.

Our conclusions on the bird's middle ear were that the muscle does oppose a positive air pressure against the drum membrane. It supports not only the drum membrane but also the columellar system from pronounced medial displacement. The negative pressure against the lateral surface of the drum membrane is opposed in a similar way through the elastic ligament system, which will be discussed later under the passive traction system related to the drum membrane and columellar apparatus.

The M. tensor tympani and M. stapedius arise in the mammal concomitant with a three ossicle system replacing a columellar apparatus. Phylogenesis would indicate that the M. stapedius is analogous, if not homologous, with the M. tensor tympani of birds and the M. opercularis of the amphibians. The M. tensor tympani and its associated M. tensor veli palatini (dilator tubæ) arise as new structures derived from the mastication muscle complex as shown by Eschweiler.[12] They are therefore innervated direct by the N. trigeminus—not otic ganglion, as usually described. The functional interrelation of the M. tensor tympani and M. dilator tubæ has been hinted at by a number of writers, but has not been satisfactorily established.

The function of the M. tensor tympani and M. stapedius is variously described, and demands at least a few words, because it is important to the problem of middle ear mechanics. We offer as a suggestion that it may be possible to combine all of the described functions of these two muscles without seriously offending one or another school and perhaps clarifying an obscure physiologic point.

Politzer[34] first described these two muscles as opponents or antagonists. The M. tensor tympani through its contraction increases the drum membrane tension by displacing the malleus and incus and therefore the stapes toward the perilymphatic space. The active opposition to this medial displacement is offered by the M. stapedius in rocking the ven-

tral end of the stapes away from the vestibule. There are certain anatomic and physiologic objections to this theory of the antagonism of M. tensor tympani and M. stapedius.

The second viewpoint is admirably shown by Kato[21] in an exhaustive study of reactions, mainly in cat and rabbit. Kato found that both of these muscles may react to auditory stimuli at the same time. He regards them as synergists. He agrees therefore with Breuer's contention for birds, except that he does not regard the tension of the drum membrane as anything other than an incidental effect. Kato holds the muscles are both set in to afford protection against prolonged auditory irritation. He could not demonstrate in many trials in rabbits and cats a single visible displacement of the drum membrane due to contraction of the M. stapedius. The reciprocal innervation, physiologically essential to antagonistic muscles, does not appear to be confirmed on the basis of Kato's excellent researches. Nor is antagonistic action in keeping with the condition found in birds where but a single muscle is present.

The third point of view might be stated as independence of contraction of the M. tensor tympani and M. stapedius, and on this only incomplete data are at hand. It appears, however, that with a single muscle and elastic ligaments in a bird, replaced by an ossicular chain and two muscles in the mammal, another possibility arises. If the M. tensor tympani draws the drum membrane in, then there must be some force which pushes the drum membrane out—not the contraction of the M. stapedius. If the M. stapedius displaces the footplate outward there must be some force against which it operates which displaces it in again (probably not entirely the contraction of the M. tensor tympani). If we grant a positive thrust factor is present, then Mangold's[27] interesting account of the voluntary relaxation of the M. tensor tympani with marked lateral drum membrane displacement becomes distinctly related to the problem of middle ear mechanics and may be correlated with the function of the intrinsic ear muscles described by Wales.[38] The argument for independence of contraction in these muscles is presented by the latter in a cycle beginning with the swallowing reflex and ending in the swallowing reflex. The drum membrane position in the plus pressure phase (air injection) of the cavum tympani, brought

about by tubal closure, is adjusted by a contraction of the M. tensor tympani. The minus pressure phase caused by air absorption gives rise to medial drum membrane displacement. This is resisted by stapedial contraction until a reflex is touched off causing salivation and swallowing. It is interesting to note that salivation was observed by Mangold in cases showing voluntary relaxation of the M. tensor tympani. It is unnecessary in the scope of this paper to go into details of which the readers are undoubtedly well informed. The writer is not in a position to disagree with the idea that air is actually injected into the middle ear by tubal closure. It has already been stated that the functional interrelation between the M. tensor tympani and M. tensor veli palatini, however probable, has not been established. It is clear that the contraction phase of the M. tensor tympani and M. stapedius, because of a limited drum membrane motion, might easily overlap at the mean of medial drum membrane displacement. The Wales and Politzer conception of muscle actions at that time would be identical in so far as the movement of the ossicular chain is concerned. Similarly Kato's synergistic action liberated through the auditory stimuli might again correspond in part to this overlap position in the two muscles. The reflex in the latter instance is auditory (inner ear) in origin, while in the former two it is perhaps a middle ear stimulus, or at least a reflex of different type.

We may liken the condition to corneal and retinal reflexes, both of which involve the lids.

Inasmuch as a muscle can do nothing more than shorten, it appears almost ridiculous that the function of these two muscles has not been thoroughly established, unless some other mechanical factor is present which has hitherto not been considered. If such a factor can be established, then certain advances in the definiteness of information on the contraction of the two muscles may be anticipated. The old statement that the balance of the ossicular apparatus rests upon a balanced function of the muscles must be deleted as not in conformity with the facts.

Fifth: The bird appears to be able to shear off its fibrous external canal at will and protect its middle ear against violence from without in a manner unknown in mammals, with

some exceptions. Further, the extreme of lateral drum membrane excursion meets a support in the application of the anterior drum surface to the external canal. The dorsal drum area is similarly protected by an erectile auditory pad—a wattle-like organ, found just lateral to the dorsal drum membrane circumference. The comparative physiology of this pad is interesting in that it is held responsible for the deafness in the "Auerhahn" (Tetrao) when the bird is "drumming" during the breeding season. The pad is separated from the tendon of the M. tensor tympani and from the external canal by a bursa. It contains stout elastic fibers which are put on the stretch when the pad is displaced lateralward either through congestion with blood or through lateral drum membrane (extracolumella) movements.

The mammalian drum membrane, however, by reason of its attachment to the more fixed malleus, the insertion of the M. tensor tympani, and its intrinsically heavier structure, is capable of very limited motion. In no extreme is the secondary support offered by the external canal, or by the medial wall of the tympanum or by the bracing of the cartilaginous extracolumella as found in birds. It appears, as might perhaps be expected from a study of the bird and its habits, that the air absorption and barometric variations are more readily compensated in this form than in the mammal.

Sixth: The bird possesses the two openings in the otic capsule which have already been mentioned in the frog. The fenestra vestibuli is filled in with the columellar footplate and an annular ligament strikingly similar to the relations found in mammals. The hinge action in the tilting of the stapes is, however, less pronounced. The fenestra cochleæ is somewhat larger in proportion to the footplate in birds than in mammals. In some forms (goose) this window is not directly related to the tympanic cavity but is placed in contact with the vena jugularis, and reminding one, in a way, of the extratympanic position of the membrana tympani secundaria in the frog. The relatively small round window of the mammal may be interpreted into terms of smaller compensations for mass displacement of the perilymph than in the bird. This is strikingly in keeping with a purely mechanical effect due to the peculiar differences in drum membrane mobility. The appli-

cation of the membrana tympani secundaria to the vena jugularis is of first importance in the relation of intratympanic pressures to that of the perilymph and will be considered later.

Seventh: The bird, like the frog, possesses a passive traction system in relation to its middle and inner ear. The elastic ligaments appear to have a very definite office in limiting the amount of excursion of the sound transmitting apparatus —particularly its outward excursion. These ligaments also limit the thrusts of the sound transmitting apparatus upon the perilymphatic space. The elastic ligaments in the bird, which have been described in three sets, are placed to limit the lateral drum membrane excursion. They also adjust the columellar parts during this excursion and allow mass displacement of the perilymph with a minimum pressure development. The attachment of the footplate is distinctly elastic, as is also the membrana tympani secundaria at the round window. The latter may be regarded as a compensation opening in all forms. A large amount of drum membrane movement may directly affect the perilymph through the sound transmission system. The size of the membrana tympani secundaria may be considered in terms of displacement at the oval window to allow unusual mass shifting of liquid. Its relatively large size in birds and frogs may be readily explained on this basis, and similarly its small size in the mammal.

Finally: The entire middle ear apparatus appears from its ancestral history to be definitely set in for variations in drum membrane position and not in terms of tension. These variations in drum membrane position arise from two distinct causes on account of the closed tubes. They do not correspond to the causes of drum membrane fluctuation in the frog, where the tube is open and where air is actually injected during inspiration. The first of these causes is due to air absorption and the second to barometric variation. Both of these causes will result in drum membrane displacement, and neither, per se, has any very direct relation to the sound transmission problem.

It appears from the phylogeny that the mechanical requirements in the transference of sound vibrations in air to the watery medium of the perilymph are fulfilled with a dehiscence in the otic capsule (the oval window), and the devel-

opment of a connection apparatus (columella, ossicular chain) from the catchment area (drum membrane). The appearance of the second opening (round window) seems to arise as an adjustment factor to a variable drum membrane topography. This variability in drum membrane position is primarily due to respiration in the frog with open tube, and secondarily to displacements arising because of air absorption or barometric variations in forms with closed tubæ. The sound transmitting apparatus may therefore be resolved into two distinct functions: the function of transmitting sound vibrations from the drum membrane through a solid medium (columellar, ossicular system) to the liquid of the perilymph; and second, an adjustment apparatus to allow for compensation in the system due to the variable drum membrane position.

A structural transition from bird to mammal occurs in the suppression of the quadratum; the formation of a definite annulus; the development of a three-part ossicular chain; the separation of middle ear complexes one from the other; a more immovable drum with a definite pars flaccida; a controlled tuba; the development of two muscles, a new M. tensor tympani, which arises out of the mastication muscles; and a persistence of a stapedial muscle comparable to the M. tensor tympani of birds. It appears that the ossicular chain preserves the old function of a columellar apparatus. Its bent-lever condition is more dependent on the factors developing the incus than those associated with either malleus or stapes (see later). That the contraction of the M. tensor tympani and M. stapedius have an effect upon acuity in hearing cannot be denied. The result may be in part central in terms of attention or actually damping on a mechanical basis. However, that this is the prime phylogenetic function is extremely questionable. Perhaps a comparison may render this more apparent—i. e., the difference between a prime phylogenetic or older function and a newer superposed function may be readily seen in the eye. It is known that narrowing the palpebral fissure increases the acuity in vision. The stenopaic slit eliminates astigmatic error, and a contraction of pupil sharpens the visual field. This result, however, is accidental in closing the lids. It is explained by the discharge of the normal sleep reflex associated with a relaxation of the M. levator palpebræ

superior. The prime function of the lid is directly associated with maintenance of the watery medium for the cornea. It is adjusted by definite corneal reflexes which are distinct from the cycle to the lids from the retina—the reactions to light irritations. The retinal responses are again indicated in the same sleep reflex. To investigate the lid reflexes dependent on light and to disregard the corneal reflexes would be unscientific. To disregard middle ear function results because inner ear adjustments appear so self explanatory is not in keeping with the trend of modern investigation.

At the present time the actual transmission of sound vibrations through the ossicular chain is possible of definite physical investigation. There are widely contrary opinions on the function of the middle ear muscles and on the method of the registration of sound pulses at the end organ. It appears therefore that the possibilities in structural detail and the probabilities of phylogenetic significance must be seriously considered. The fact remains that individuals with malleus and incus gone may still hear, particularly through the telephone. They suffer a decrease in intensity of hearing for usual air transmitted sound, dependent largely on the size of the catchment area of the drum membrane in relation to a corresponding but inefficient area at the medial wall of the tympanic cavity.

The elastic character and function of the bird's middle ear ligaments has been overlooked for over half a century, as well as the definite sequence of columellar adjustments to drum membrane displacement. It may therefore be well to examine the middle ear region of the mammal to ascertain whether there are any other passive factors operating, apart from drum membrane elasticity, which are present in all forms. The problem of the elastic ligaments in the middle ear complex of mammals may be divided into two definite ones: first, the position of these ligaments, and second, their function. These are problems of almost indefinite length and much must be done, particularly in variable forms, before scientific conclusions may be attained. We present this brief preliminary survey to emphasize the line of thought to be followed. We report a confirmation of the theoretical presence of elastic ligaments in the baby cat as extremely stimulating toward some

sort of defiinte solution—if a definite solution may be attained.

If we disregard aberrant aquatic forms, such as the cetaceans, the usual mammals may be divided into two very general classes based on peculiarities in the middle ear. The first variety, like man and the guinea pig, has a ligamentous support to the ossicular chain. In the second variety the malleus is attached by bony union of its processus anterior to the annulus like the carnivores (cat, for example). These differences do not seem to interfere at all with acuity of hearing, as both cat and guinea pig are possessed of excellent capacities in this respect. But the variations undoubtedly play some important part in middle ear mechanics which demand investigation.

The common cat is an animal with a remarkably well developed sense of hearing and differs from man in a number of particulars: first, a relatively long manubrium mallei is attached to the drum membrane, while the caput is relatively small; second, the bony union of the stout anterior process to the annulus is pronounced; third, the incus and stapes are relatively small; fourth, the M. tensor tympani is almost completely intratympanic in position; and fifth, the development of the bulla posteriorly, which may be disregarded, because it after all merely contributes to size of the tympanic space.

The fixation of the malleus is accomplished through attachment of the manubrium to the drum membrane; the bony ankylosis of the anterior process; a heavy reinforcing white fibrous ligament uniting mainly the anterior process to the annulus; the reciprocal incudomalleolar articulation which is sometimes three-part, sometimes two-part; and the attachment of the M. tensor tympani to an especially heavy muscular process which is not directed the length of the tendinous fibers but at an angle to them.

Two series of the entire middle and inner ear region of a newborn cat were cut in paraffin and stained with resorcinfuchsin and differentiated in picric alcohol. The elastic connective tissue prepared with this technic is blue black, while the white fibrous tissue remains feebly stained. Examination of these two series reveals the following points:

First: The elastic fibers of the drum membrane are relatively poorly developed, as noted by Watsuji.[40] The mem-

brane itself is made up for the most part of interlacing bundles of white fibrous connective tissue with few elastic elements.

Second. The ligaments attaching the malleus are of white fibrous tissue, which is particularly well developed in the attachment of the ankylosed processus anterior.

Third. The capsular ligament of the incudomalleolar articulation is elastic in character and the wedging in of the incus into the reciprocal articular surface of the malleus is very prominent.

Fourth. The posterior ligament of the incus attaching the short horizontal process to the posterior superior wall of the middle ear cavity may be definitely separated into two components: a superior lateral ligament of white fibrous tissue which has a wide superior attachment and whose fibers converge upon the superior surface of the short process; and an apical ligament which is directed downward and composed almost exclusively of stout elastic fibers. This observation on the elastic apical ligament in the cat (dog and guinea pig may also be included) confirms the work of Schmidt,[35] who described these two incudal ligaments in the human being.

Fifth. The capsular ligament of the incudostapedial articulation is also elastic in structure.

Sixth. The ligamentum annulare and the deep surface of the membrana tympani secundaria are made up of elastic connective tissue.

It appears therefore that all the ligaments associated with the incus and stapes are elastic in character except the posterior superior ligament of the incus. The apical elastic ligament of the incus in particular is suggestive because the incus is the passive bone of the series—i. e., it has no direct muscular attachments. Accordingly it lends itself well toward a comparison with the cartilaginous extracolumella of birds with its associated ligaments, particularly the columellar squamosal ligament of Platner, which has a pronounced function. Theoretically therefore the incus is a neglected factor in middle ear mechanism, and the presence of the elastic ligaments suggests passive factors of return of individual ossicle movements. This is in keeping with the recent investigations of Mangold, Kato and Wales, and con-

trary to the commonly accepted view of Politzer concerning the antagonism of M. tensor tympani and stapedius.

When we examine the method of fixation of the stapes footplate at the fenestra vestibuli and the character of the membrana tympani secundaria in the cat, we find a striking resemblance to conditions as found in the bird. The ligamentum annulare of the stapedial as well as that of the columellar footplate are composed almost exclusively of elastic fibers. These fibers are perhaps relatively shorter in the mammal, where the stapedial footplate movement is more limited and perhaps even mechanically inhibited from marked inward displacement. The membrana tympani secundaria is also formed by elastic fibers, particularly on its deep surface, and the structure of the membrane in cat and chick is surprisingly alike.

We are now prepared to consider the mechanical features in the Wrightson theory. We shall quote rather extensively from his recent work because it agrees with the commonly accepted conception of sound transmission. It disagrees only from other theories in the displacement responses of the membrana basilaris and the method through which the auditory cells are affected.

According to the Wrightson theory, we must look upon the cochlear mechanism as a weighing machine. That is to say, the membrana basilaris is an adapter membrane piston whose function it is to transform the vertical waves in the perilymph liquid into transverse displacements at the hair cells. It is not our purpose to offer objections to the extensive physical research in regard to the form of sound waves. We object rather to the function which is ascribed to the middle ear. We are not satisfied with the statement as to what is cause and what is result in the interpretation of the sound transmiting complex.

"When the rarefaction part of the air wave advances on the drum membrane, the atmospheric pressure which exists in the middle ear drives the drum membrane backward." (Fig. 1.)

P. 50. "The malleus and incus are firmly attached to both the drum and the stapes, so that the fenestra ovalis is pulled outwards, and the atmospheric pressure of the middle ear

through the fenestra rotunda also follows up the displacement caused by the outward motion of the stapes. We have thus power applied at the stapes to produce a positive to and fro motion in the liquids in the cochlea."

P. 54. "The greatest excursions observed at the extremity of the manubrium of the malleus were 0.76 mm., those of the long process of the incus 0.21 mm., and, according to Helmholtz, those of the stapes 1/18th to 1/14th mm., or a mean of 0.06 mm. These measurements are, however, the result of extreme condensations and refractions of the air in the external meatus or in the tympanic cavity. On the other hand, during vibrations caused by sound, the excursions of the stapes are limited (Gelle); and Reimann justly states that with weak but still plainly perceptible tones these motions of the stapes must be so small that they cannot be seen even with the most powerful microscope" (quotation from Buck after Politzer).

P. 56. "It is difficult to realize that these minute motions can be ordinary molar motions, but we have a proof supplied in the action of the phonograph. In this instrument the almost microscopic groove upon the wax of the receiver cylinder caused by the mechanical vibration of the one membrane is made to deliver up to a second membrane an almost exact imitation of the vibration of the first which produced the grooves in the wax. Molar motion is clearly the cause of the reproduction, and therefore it is reasonable to regard it as being the cause of the production."

P. 93. "We have now to consider two other membranes in the cochlea, the basilar and Reissnerian membranes, which form a closed triangular space (canalis cochlearis) running spirally from the base to the apex of the cochlea and enclosing liquid endolymph which entirely fills the triangular spiral space and cannot mingle with the perilymph, a liquid of different chemical constitution, which entirely fills the vestibular and tympanic passages. Any displacement of liquid occurring at the stapes can pass into the tympanic passage by the displacement of the Reissner and basilar membranes instead of going through the helicofrema, if the resistance is less through the former channel. Of course, no particles of liquid pass the membranes, but the pressure causes displacement into the tympanic passage, and this displacement proceeds onwards to

the fenestra rotunda, where it gets relief in the middle ear, which is normally at the atmospheric pressure."

P. 95. "Thus the displacements of the fenestra ovalis, Reissnerian and basilar membranes, and the fenestra rotunda are equal, and the internal membranes move as though they formed part of the liquid."

P. 96. "It is evident that, taking into consideration the relative areas of the basilar membrane and the helicotrema, the line of motion of the displacements will follow that of least resistance, or through the basilar membrane, especially in the case of such rapid displacements as we have in sound waves."

P. 97. "If there were no basilar membrane, but a rigid partition, all the displacement produced at the fenestra ovalis would have to pass the helicotrema, and the reduction of area would cause a considerable loss of pressure in the tympanic passage owing to fluid resistances. With a flexible basilar membrane the displacement is passed through to the tympanic passage, distributing itself along the gradually widening membrane towards the helicotrema."

P. 121. "The stapes and basilar membrane move together because connected by inelastic liquid, which controls completely their movements. The stapes and drum move together because connected by an articulated chain of ossicles. Thus the pressure of the air wave on the larger area of the drum is passed through the bent levers of the ossicles to the much smaller area of the stapes. This increases the unit pressure in the liquid of the labyrinth like a small intensifying press, the increase of pressures implying a corresponding decrease of displacement and motion and therefore of velocity. The drum membrane transmits its energy through the ossicles in a direct chain of bones, so that as the varying pressures of the air wave arrive at the drum they immediately meet the resistance of the inelastic liquids in the labyrinth and act upon the combined resistances of the tensor tympani and stapedius muscles; also on the elastic connections of the basilar membrane and other resistances."

P. 46. "Dr. Keith points out that if the auditory human ossicles have to do with the regulation of the pressure of the perilymph and endolymph, the arrangement of the muscles in connection with the chain of bones becomes clear. In the first

place, the two elastic muscles under initial tension are continually acting in opposite directions on the chain of ossicles to balance them. When the tensor tympani contracts it has the effect of plunging the stapes deeper in its fenestra and increasing the pressure of the fluids in the inner ear; the stapedius has exactly the opposite effect, and through the balance maintained by these muscles the pressure of the liquids in the inner ear is regulated."

Keith in the appendix of the book gives a rather exhaustive account of the ear relations in various forms, and inasmuch as he devotes some space to bird mechanics it is important to note his comments.

P. 222. "The ear of the bird is likely to give us a clue to the mechanism of the cochlea for the following reason: All the evidence at our disposal leads us to believe that birds and mammals have been derived from a common ancestry; they have become very different in appearance because they have specialized along totally different lines. We feel certain therefore that the ears of birds and of mammals are modifications of a common form and that, although they may differ greatly in detail of structure, yet the underlying principle on which they work must be the same. For that reason I am to devote a few paragraphs to the ear of the bird. Retzius has published excellent sections of the bird's ear."

P. 221. "Now, when we are in doubt as to the exact mechanism of any obscure structure in the human body, there is always one source of evidence open to us—that of comparative anatomy. To help us in deciding as to what may be the exact manner in which the cochlea converts sound impulses into nerve stimuli I am to refer to the cochlea of the bird for the following reasons: There can be no doubt the ear of birds has an analytic power; many of them can sing and have, we must suppose, the power of appreciating song; they distinguish one call from another. Several kinds of birds imitate human speech; such imitation would be impossible unless their ear appreciated and distinguished the various modifications of tone combined in our speech. We must therefore presume an analytical power in the cochlea of the bird."

P. 222. "In the case of the bird, a single bone—the columella—connects the drum with the oval window. While the

outer end of the columella is fixed to the drum, its inner end expands into a footplate which is fixed into the margin of the oval window by a ligamentous membrane. The lower and hinder borders of the footplate are more tightly fixed in the window than the upper and anterior margin, not unlike the manner in which the stapes is attached in the fenestra ovalis of the mammalian ear. The movements of the columella are more like those of a lever than of a piston; it is hinged to the lower margin of the oval window. Internal to the footplate is the cavity of the vestibule, filled with fluid. A horizontal partition is drawn across the floor of the vestibule, stretching from the lower margin of the oval window, which is occupied by the footplate, to the opposite or inner wall of the vestibule."

P. 223. "It will be noted that the middle passage (scala media) of the cochlea is separated from the cavity of the vestibule by a thick folded membrane containing many blood vessels—the tegmentum vasculosum. It represents a combination of Reissner's membrane and the vascular body (stria vascularis) of the mammalian ear.

The horizontal partition just described forms the floor of the vestibule and the roof of the lower or tympanic passage of the cochlea—at least the terminal part of that passage. The round window lies immediately below the oval window. It is closed by a strong but loose membrane, which is placed between the lower end of the tympanic passage and the cavity of the middle ear or tympanum.

Now, in considering the mechanism of the bird's ear we may omit from our calculations the movements of the tegmentum vasculosum; it is a slack membrane and may be regarded for our present purposes as forming part of the fluid which fills the vestibule. When, then, the outer end of the columella is set into vibration by the drum, its footplate will carry the impulses of the drum to the fluid filling the vestibule. As in the mammalian ear, we may distinguish four phases in each vibrational cycle. In phase I the footplate, starting from its point of rest, moves or rotates inwards, displacing a minute quantity of the vestibular fluid. The vestibule has firm walls everywhere except that part of its floor formed by the basilar membrane. The membrane yields, dis-

placing the fluid contents of the lower passage and forcing outwards the round membrane. In phase II the footplate returns to its starting point, and the basilar membrane and organ of Corti rise to their equatorial level. In phase III the outward excursion of the footplate continues, and the basilar membrane rises so as to become convex upwards; the round membrane is drawn in. In phase IV all these parts return to rest."

There are a number of important features in the Wrightson hydraulic weighing-engine hypothesis of inner ear function which are clearly related to middle ear mechanics. They must therefore be considered from the standpoint of the causal factor—sound—in its behavior to the middle ear complex, and to the perilymph itself. It is essential that these points be clearly stated because Wrightson, an engineer of unquestioned ability, has interested himself in the problem for forty years, and Keith, who contributes the confirmatory evidence from an anatomic and physiologic standpoint, is an investigator of recognized attainments. If facts have been presented, we are dealing with differences in opinion regarding their interpretation. If, however, the facts have not been presented, then we are dealing with an attempt to make observed data conform to an hypothesis and may offer criticism which is entirely outside of differences in opinion or personal equation.

Briefly it will be seen Wrightson considers that the sound wave produces a molar or mass drum (see Fig. 1) membrane displacement. He believes that the ossicular chain functions as an "intensifying press which increases the pressure and decreases the velocity." The bent-lever transformer (ossicular chain) is regarded as balanced by two muscles—M. tensor tympani and M. stapedius, which may also have the office of acting as regulators of perilymphatic pressures. The pressure in the labyrinth is considered equal to that of the tympanic cavity (atmospheric) because of the relation of the stapedial footplate and membrana tympani secundaria to the tympanum. The membrana tympani secundaria is assumed to undergo displacement excursions dependent on the in-and-out movement of the stapedial footplate because the otic capsule is an inelastic container, excepting at the oval and round windows, and filled with an incompressible liquid. The displacement

pressure caused by the stapedial movement is applied to its compensation area, fenestra cochleæ, through the membrana basilaris. This displacement arises because the resistance through this membrane is less than the friction head through the helicotrema. The membrana basilaris is therefore construed as a piston lying between the two openings in the cylinder—the oval and the round windows. The position of the Corti arches to the basilar membrane makes possible a tilting of the organ of Corti during the up-and-down movements of the membrane and results in a transformation of vertical movements into a lateral shifting of the hair cells at the tectorial membrane. The cilia would therefore respond to displacement forces applied at right angles to their length. The analyzing capacity of the end organ could in this manner be translated into a delicate weighing machine of pressures in the liquid.

Keith calls attention to the similarity in position of the essential parts of the inner ear system, notably in the bird, and also includes certain mammals and other forms of terrestrial vertebrates in his report. Inasmuch as the bird is a chief factor in his considerations, the relations in the bird may be also regarded from a somewhat different point of view later on.

We propose to ask several questions and develop in the answers to each one wherein the facts do not conform with the Wrightson assumptions. We will also show wherein the comparative anatomy and physiology fail to substantiate the Wrightson hypothesis.

I. Do the members of the ossicular chain act as an "intensifying press" which decreases the amount of excursion at the stapedial footplate in response to the drum membrane displacements occasioned by sound vibrations?

Practically all modern theories of hearing assume: (1) that sound vibrations produce a mass movement in the drum membrane; (2) that the ossicular chain acts like a lever transferring the membrane movements; and (3) that the liquid contents of the internal ear are displaced by mass stapedial reaction. There is, however, another method by which sound vibration may register an effect on the end organ of hearing. The writer wishes to discuss this method at some length.

Hence it will be necessary to consider the mechanical features of our problem rather fully. The accepted conception of ear mechanics is practically the one made famous through Helmholtz's work,[20] although Bell, and Bell[2] in 1812, presented the identical proposition, together with a figure to illustrate the leverage action of the ossicles.

Let us first consider the differences in the behavior of concussion and sound waves in air. When a gun is discharged two varieties of air displacement arise: a concussion wave, which is due to the mass movement of the air, and a molecular displacement in the air which transmits the sound of the report. The explosion wave travels rapidly from the source, but its velocity is decreased as it is diluted out in the distance, because of the resistance in the air which it must overcome. The velocity of the sound wave, however, does not behave in this manner and remains practically constant so long as the medium through which it is traveling is physically constant. The rapidity with which a sound wave is carried is dependent on the density-elasticity coefficient of the medium through which it is being transmitted. If one is walking on a railroad track, and repairers strike the rail one mile away (roughly, 1,600 m.), the concussion wave begotten in the rail and in the air will be practically, if not entirely lost, but the sound of the tap comes to the ear through the steel in about one-third of a second, while the air transmitted sound will arrive roughly four and one-half seconds later. This indicates that the wave length of a given sound through steel is about fifteen times the length of the same pitch in air.

This fact, however, does not bear any definite relation to the efficiency of the two media in respect to their capacity for transmitting sound. Speed, in other words, bears no definite relation to quantity, and the air presents a slow but well adapted material not only for the origin of sound but for its transmission as well. If one places a rod of glass and one of vulcanized rubber of equal length and thickness upon a resonator and applies the stem of the vibrating fork to one end, it is found that the resonator speaks out equally well. This occurs in spite of the fact that the transmission through glass is ninety times as rapid as that through vulcanized rubber.

The wave length of a given sound pulse in air therefore

varies with its pitch, and is equivalent to the distance traveled in a second, divided by the number of vibrations. For this reason rapid motion toward the source of the sound will materially increase its pitch. It must also be remembered that air is a relatively slow transmitter of sound vibrations. The wave lengths in air, while they vary from 5 m. to about 3 cm., are short when compared with the waves of similar vibrational frequency in other media.

Sound is transmitted by a longitudinal molecular displacement, and its amplitude therefore lies parallel to the direction. The molecular displacements in a single pulse may be represented in four phases, each of which occupies the time of one-fourth of the frequency. The first phase is that of the molecular advance from a position of rest; the second is the retreat to the original position; the third is the swing-back, equal to the amount of the first motion; and the fourth is a readvance to the position of rest. This means that the sound vibrations travel by alternate rarefactions and condensations in the medium. It must also be remembered that during the first and fourth phases the molecular motion is in the direction of the wave propagation. In the second and third phases the molecules retreat as the sound advances. This is a distinct pendular motion and may only be represented graphically by translating the longitudinal displacements into transverse ones. It will therefore follow that the energy or intensity is quite independent of the wave length but not independent of the pitch. The higher the pitch, the greater will be the number of independent waves per unit of time. The rapidity of transmission is dependent on the medium, but independent of the power applied or the amplitude created.

The amplitudes or intensities of sound vibrations therefore represent the distances of actual molecular displacement which in ordinary sounds are of microscopic values, and, in the case of weak intensities, ultra microscopic measurements. Calculation has been made on the amplitude of an F sharp pitch when produced by a pipe actuated under an air pressure equal to a 40 mm. column of water. The amplitude of this sound vibration at 115 m. has been computed to be 1/25,000th of a millimeter. Let us compare the actual sine curve of this frequency and amplitude with that obtained from the oscillation

of a tuning fork prong as recorded on a smoked drum. The tuning fork prong vibrating at a frequency of 181 per second will graphically reproduce the molecular behavior. The resulting curves will, however, be of transverse, not a longitudinal waves; second, the wave length will be tremendously increased; and third, the amplitude will be enormously exaggerated. The sine curve under the conditions indicated above consists in reality of a line 1.8 + m. long, with a deviation of 1/25,000th mm. Contracting the wave length to 1 cm. and magnifying the amplitude with a corresponding increase will only result in a deviation from the straight line of .0072 mm., or roughly the diameter of a human red blood cell.

The sine curve figures are pendular motions which graphically show molecular displacements. They are unquestionably correct if one remembers they represent transverse motions and not longitudinal ones. A misconception of the actual behavior of the sound pulse might readily come about on the basis of the sine curve figures produced by Wrightson and others. It has been estimated under the conditions noted in the F sharp pitch, at the distance of 115 m., an actual drum membrane movement would not occur above 1/1,000,000th mm., or, in other words, a mass movement in the membrane would probably not exceed 1/100,000th of its thickness. We are likely to visualize these alternating condensations and rarefactions in the air, due to sound vibrations in the form of explosion waves.

It is well to bear in mind that the oscillations of a tuning fork bear no relation to the wave length and the amplitude of the sound wave arising from this source.

It is usually conceded that the impingement of sound vibrations upon the drum membrane begets a mass response in the membrane. This may be illustrated by quoting from Daniel's[10] Textbook of Physics, from which the information regarding the F sharp pipe was taken. "Motion is thus communicated through malleus, incus and stapes; but the stapes moves only two-thirds as much as the handle of the malleus—another step in the increase of the force and the diminution of the amplitude of the vibrations conveyed to the ear by the air." The other factor mentioned was "that the handle of the malleus is wielded with considerable force—one step in the increase of

force of the aerial vibrations on their way to the inner ear." It will appear that the mass movements in the drum membrane occasioned by increasing and decreasing the air pressure in the external auditory canal have been carried over directly to mass responses in the drum membrane without reference to the amplitude and force of sound vibrations themselves. Daniel, for example, offers on suggestion how a movement of 1/1,000,000th mm. at the handle of the malleus could undergo a one-third reduction in being transmitted to the stapes, nor does he mention the possibility of an elastic membrane absorbing a surface compression of 1/100,000th of its own thickness without an actual mass response taking place.

Wrightson has constructed a schematic working model to indicate the mechanics of sound transmission. This model differs in no essential particulars from the usual schemes except in a direct connection of the footplate of the stapes to the membrana basilaris. The motion in the drum membrane is actuated by a bent rod, clearly a mass displacement form. The ossicles are represented by a double lever with two hinges; one element, the malleus and incus, and a second hinge member, the tilting of the stapes, moved by means of the first. The muscles (M. tensor tympani and M. stapedius) are shown by two elastic bands which operate to balance the chain. The mechanical relation between the stapedial footplate and the basilar membrane and inner ear structures is also represented. While the scheme is merely presented for the purpose of visualizing the arrangements and motions in the various parts, several mechanical objections may be made. The first of these is the frequency with which the apparatus must respond; the second, the actual power applied to make it react; and the third, the distance through which the original activating factor must operate. We must consider not only the feasibility of the scheme but the minimum conditions under which it must function.

Let us take the same low frequency F sharp — 181 vibrations to the second and apply it to Wrightson's machine. A reciprocal apparatus which will respond to 181 individual impulses per second must indeed be delicately balanced, particularly when it represents a double lever of the form indicated. Carry the frequency to C_6 on the piano — 4,096 vibrations per second, well within the range of usual tone, and a

mechanical motion of this kind becomes inconceivable in the form of a complicated hinge—give and take. The most delicately balanced supercentrifuge runs about one-tenth this speed and approaches a limit of physical possibility in the practical construction to withstand the centrifugal force.

It must be remembered that sound pulses are ordinarily of minute power value. Ten thousand people might readily hear the energy liberated by a single cricket. Yet one is asked to believe that this energy is sufficient to swing 20,000 sets of ossicles. Not only must the inertia of the mass be overcome but a relatively large amount of perilymph must also undergo shifting. Wien has computed that the pitch 1,600 requires the least amount of energy to register upon the end organ. He states this amount for an instantaneous tone is minus 1.10-15th erg. If Wien's figures are correct, then we may translate this energy readily once we know the weight of the ossicles and liquid contents of the cochlear system. Assume this weight to equal 125 mgs. The amount of energy required to lift a nickel five-cent piece 2 mm. from the surface of the table is the gram-centimeter unit. If minus 1.10-15th erg will move the weight of 125 mgs., then the gram-centimeter will move a block of concrete 200 feet by 50 feet and 35,000 miles long. The power applied by sound vibrations is therefore insufficient under normal conditions to move the mass, particularly when the entire system is aperiodic and a summation of energy impossible.*

It has been known for many years, and recently substantiated by Haldane (45), that the ear has an extremely fine interval discrimination. Haldane maintains that the trained ear can at certain pitches recognize the dropped pulse up to a frequency of 250th of a second. This deadstop in a rapidly swinging system makes it impossible to conceive a mass reaction because the inertia of the system must be considered

*NOTE. Since writing this article Kranz has checked Wien's results, using the thermophone as a sound source under rigorous test conditions. He finds Wien's figures that it requires 100,000 times the energy to hear 64 than it does 1600 are essentially correct for 128 and 2048 respectively. The minimum rate of energy flow is, however, 10,000 times as great as that computed by Wien. The particle displacement at 2048 p.p.s. was 0,025 micromicrons or one-fortieth millionth mm.—Phys. Rev., Vol. 17, 1921, p. 384.

zero. But this in reality cannot be the case. Wrightson himself assumes a factor of inertia because he calculates the resistance head to liquid displacement through the helicotrema is sufficient to divert the pressure from the scala vestibuli into the scala tympani through the vestibular and basilar membranes.

The writer cannot agree to the proposition that mass drum membrane displacements arise as reactions to sound vibrations of usual minute amplitude. We realize, however, that molecular forces may result in mass movements. The transformation of the sun's rays on the black surface of the radiometer causes a molecular bombardment of the air molecules of the partially exhausted tube. Here we are dealing with the effect of radiant heat, and the effect is an obvious movement of the vanes. There are limits to intensity of hearing just as there are limits to the reaction in rods and cones to light. When the amplitude of the sound waves becomes excessive and the drum membrane mass movements arise, we are undoubtedly well beyond our possibilities of intensity of hearing. In the writer's opinion the entire mechanism is such that the problematic mass movements in the drum membrane and in the ossicular chain cannot have anything to do with hearing.

Our answer, then, to the first question is this: In all probability no drum membrane displacements occur in the human ear under the usual conditions of hearing; nor is there any mass response in the ossicular chain and the perilymph. On the contrary, all such mass responses seem decidedly opposed to the efficient working of the apparatus. In birds no delicate lever system between the drum membrane and the perilymph is to be found. The movements in the columella occur only as a result of forces which are easily measurable. Many animals, moreover, of acute hearing (cats, for instance) have a bony ankylosis of the malleus to the annulus.

II. Is the antagonistic action of the M. tensor tympani and M. stapedius responsible for a balance in the ossicular chain?

The comparison of these two muscles with two elastic bands is unobjectionable. It is, of course, a mere figure of speech intended to make certain mechanical relations clear to the uninformed. But we must question the assumption that these two muscles act in opposition. This assumption was evidently made without reference to the recent detailed and wonderfully

graphic work done by Kato and by Mangold. In the light of this work the assumption of Wrighton becomes untenable as far as the mammalian ear is concerned. Birds also enjoy a fine sense of hearing and have only one muscle associated with their sound transmission system.

It was pointed out that Mangold's researches on cases of voluntary relaxation and contraction of the M. tensor tympani in man do not harmonize with the older Politzer conception of antagonism. It was also stated that Kato's excellent observations in the cat and the rabbit deduce a synergistic action in these muscles. Further the contraction of the muscles is in part a response to prolonged auditory stimulation. This must necessarily be the case, because the reflex system is too slow to be operative in terms of speed of sound itself. It may be that a serious misconception of the action of these muscles has come about. This misconception may be due to translation of drum membrane movements into terms of usual sound wave reactions, and from observation of the muscles under certain conditions without reference to other possibilities and probabilities. Finally there are certain unconsidered factors which may affect the middle ear mechanics—the presence of elastic ligaments.

We may therefore answer question II. The assumed antagonistic action of the M. tensor tympani and M. stapedius is not a fact except in a very restricted way. The alleged balance of the ossicular apparatus through muscle contraction in the manner described by Wrightson still remains to be demonstrated. Wrightson grants a balancing of the ossicular chain through the opposed action of M. tensor tympani and M. stapedius without suggesting why this is necessary. He does not even indicate what the disturbing element in balance may be. Why may not the ossicular chain be considered already balanced without muscular pull at all? The complete answer to this question will be found at the end of the paper when the comparative anatomy and physiology of the middle ear region are discussed.

The balance in the ossicular chain must logically affect the tympanum because of its close tuba. This brings up the question of the intratympanic pressure, the perilymphatic pressure and the relation of these two, because Wrightson maintains

there is a distinct relation between them. The first part of this question may be considered presently; the second will be deferred until the perilymph container has been discussed.

III. Is the intratympanic pressure equal to that of the atmospheric?

Intratympanic pressure is conceived by Wrightson to be atmospheric. This is clear from the excerpts given and from his figure. He furnishes, however, plenty of evidence why it should not be considered equal to atmospheric pressure. It is well known that any moist vascular area exposed to an air pressure higher than that of blood-lymph tension may absorb oxygen, provided the surface membrane is permeable. It is also well known that air is absorbed from the middle ear cavity, indicating tubal insufflation as a remedial measure in cases of tubal closure. That some pressure differences may occur is indicated by Wrightson. For he grants a reflex cycle: "Swallowing or yawning causes a slight opening of the eustachian tube, which restores the equilibrium." He also appears to assume that this equilibrium is adjusted by a middle ear function because "increases in pressure in the middle ear due to bending of the drum membrane between the attachment of the malleus and the periphery of the drum might cause a slight rise in pressure in the middle ear, but such increases would not be transmitted to the stapes, as the same rise in pressure acts through the fenestra rotunda, thus balancing that acting on the fenestra ovalis." The contention of Wrightson that the middle ear is at atmospheric pressure is open to serious objection. He appears to show the pressure is never that of the atmosphere except at the time of tubal opening. He also seems to indicate that perilymphatic pressure may only be atmospheric at this time because the intratympanic pressure directly affects the perilymphatic pressure through the two windows (fenestra vestibuli and fenestra cochleæ). How a reflex mechanism can be touched off without a cause is in this instance not explained.

Wrightson's contradictory statements practically furnish an answer to question III. Intratympanic pressure may not be equal to atmospheric pressure except when the tube is open. The explanation of the inferred relation of intratympanic

pressure to that of the perilymph will perhaps make the answer to this question a little more obvious.

IV. Is the otic capsule, filled with liquid and membranes, to be considered an inelastic container apart from the fenestra vestibuli and fenestra cochleæ, and what relation have these two windows in preserving a balance of perilymphatic pressure which Wrightson assumes to be that of the atmosphere?

The answer to this question is extremely important, because upon its affirmation rests the entire Wrightson hypothesis of an hydraulic weighing engine. The membrana basilaris is assumed to act as a piston responding to the force transmitted by the stapes, because of the relation of the footplate to the membrana basilaris and to the fenestra cochleæ. It may be well to discuss this answer more fully because of the importance in relation to this, as well as any other theory or hypothesis connected with inner ear mechanics. We may disregard what might be termed a quibble and assume that the highly elastic petrosum is inelastic in so far as the minute power applied to the perilymph from the sound reactions of the stapes is concerned. There are, however, a number of objections which Wrightson as an engineer might not realize. But Keith, his adviser for the anatomic and physiologic aspects, either did not know these objections or he disregarded them. The criticism of the Wrightson hypothesis of a weighing analyzer must not be made on its theoretic possibilities but on its workability under the conditions imposed.

It has already been granted that the petrosum is relatively inelastic or incompressible in so far as the power of the sound vibration applied is concerned. For otherwise it would be impossible to analyze the Wrightson hypothesis at all. We assume, then, an inelastic container. A minute stapedial movement, according to Wrightson, will displace the basilar membrane like a delicate piston, because this membrane offers less resistance than the friction to a perilymphatic flow through the helicotrema. A displacement of the basilar membrane must occur because of its position, situated between the stapedial footplate and membrana tympani secundaria.

Keith states definitely that the otic capsule may be regarded as inelastic apart from one point which he makes in connection with perilymphatic pressure regulation. It is difficult to determine why these writers accept the work of Bezold[5] on the

molar properties of the sound wave at the stapedial footplate and completely ignore the exhaustive researches started by this writer in 1880 and completed in 1908 in reference to this particular problem. Bezold's work is not only typically careful in the matter of measurements, but it is checked by confirmatory evidence with a labyrinth manometer. Bezold is not convinced that the membrana tympani secundaria has any definite response to sound vibrations in the perilymph. His experiments in the reactions of the membrana tympani secundaria to variations in intratympanic pressure indicate a measurable fluctuation in this membrane without a response at the stapedial footplate. This, according to Wrightson, may not occur. These fluctuations of the membrana tympani secundaria are due to areas of less resistance than that at the stapedial footplate, in the aqueductus vestibuli, aqueductus cochleæ and porus acusticus interna. Pressure at these areas gives rise to variations in the perilymphatic pressures, as is evidenced by the labyrinth manometer. Bezold not only indicates the minute blood vessels as direct adjustment factors but even includes the lymphatic system. This evidence explains the failure in response of the stapedial footplate to the measurable variations in position of the membrana tympani secundaria with an equal negative or positive pressure applied to both orifices. Bezold's arguments for holding that the membrana tympani secundaria does not respond to sound vibrations appear reasonable. The only mention which Keith makes of all this work is to say that the minute capillary adjustments may be "disregarded as a part of the liquid which fills the cavity." This in spite of his notation on perilymphatic pressure—"The tension cannot be greater than that within the blood venules of the inner ear; it cannot be greater than venous pressure. The pressure would thus vary with the venous pressure; we may infer it would support a column of mercury two to four millimeters high."

Objections might suggest themselves to the experimental evidence submitted by Bezold on the basis that his results were obtained on dead material. These objections may not obtain for the work of Kato, who analyzed this very point on living material. "The reflex contractions of the M. tensor tympani may result in a medial displacement of the ossicular chain.

At least it follows from observing the anatomic relations that if the drum membrane is drawn medialward through contraction of the M. tensor tympani, the entire chain of ossicles would also move in this direction. This movement would necessarily be carried over to the liquid of the inner ear, and the result of muscular contraction would therefore evidence itself in a motion at the round window. A number of experiments were undertaken to answer this question—whether or not movements at the round window could be observed during the reflex contractions of the M. tensor tympani. The fluctuations would necessarily occur in a very restricted region and might be observed with a Westien magnifier in the behavior of the light reflected from the surface of the membrane. It was demonstrated in every instance that, at least with this magnification, no displacement of the membrana tympani secundaria could be observed as long as the intrinsic muscles were intact. Convexing of the membrane toward the tympanum was, however, demonstrable when the tendon of the M. stapedius was severed or that muscle incapacitated through destruction of its nerve. Cutting the M. tensor tympani eliminated this movement."

We read some time back that perilymphatic pressure is atmospheric and that it is regulated by the apposition of the two windows to the tympanum. Therefore when the pressure falls or rises in this cavity there is no displacement at the stapes or round window because they are both applied to the tympanum. Bezold's experiments, however, clearly indicate that this is not true. Keith himself states that the perilymph pressure varies with the venous pressure. He also disregards the capillary system as an adjuster of the pressure in an equally emphatic manner. This may account for the interesting statement made by Wrightson that "according to Dr. Keith, if the auditory ossicles have to do with a regulation of pressure in the perilymph and endolymph, the arrangement of the muscles with the ossicular chain becomes clear." This would indicate the definite conviction that a regulation of perilymphatic pressure by the muscular action is quite obvious. Wrightson's statement implies further that if we do not assume this to be the end result, the function of the intrinsic muscles is not clear. Keith's convictions in this respect, however, are not

as strong as one might anticipate. Toward the end of his contribution to Wrightson's book we observe the following passage: "The tensor tympani *could* press the stapes inward and raise the pressure within the ear; the stapedius *could* produce an opposite effect; between them they could regulate the pressure of the inner ear—*within certain limits.*" Italics are mine to indicate the sentence should end with an interrogation mark and not a period. The problem of perilymph pressure necessarily also arises in birds, and certain features in comparative anatomy and physiology must be considered.

Our answer to the fourth question is: The otic capsule is not an inelastic container, either theoretically or practically; and the two windows are not the only functioning openings in this capsule. From the determined fluctuations in the membrana tympani secundaria without corresponding result at the stapedial footplate when equal plus or minus pressures are applied intratympanically, we may infer that minute stapedial movements are compensated for elsewhere. This compensation takes place through adjustments in the venous pressure for which there is direct evidence, as will be shown later. We must therefore take up the consideration of the physical reactions in the membrana basilaris and the directed force of the minute stapedial displacements on this membrane as opposed to all other pressure adaptive areas.

V. May the membrana basilaris be considered a transformer of vertical into transverse displacements because of its relation to the stapedial footplate and the membrana tympani secundaria, and because the route through the basilar membrane offers less resistance than liquid displacement through the helicotrema?

It will be recalled that the piston action of the membrana basilaris is the keynote of the Wrightson hypothesis. This piston action supposes an inelastic otic capsule with only two areas of possible surface motion, the stapedial footplate and membrana tympani secundaria. The experimental evidence of Bezold, however, is quite contrary to this assumption. Bezold holds that the fluctuations of the membrana tympani secundaria with a closed tympanum creating both negative and positive pressures at both windows are readily observed without stapedial movements. The fluctuations of the membrana

tympani secundaria, accordingly, imply other regulatory factors, namely, those already presented in the foregoing answer. It was also noted in this answer that Keith himself believes the pressure is a variable one and dependent on the pressure in the blood vessels. The Wrightson hypothesis calls for a directed pressure response in the membrana tympani secundaria and for a piston action of the basilar membrane because of its relation to this orifice. The theoretical behavior of the liquid displacement at the helicotrema, while carefully studied by Wrightson, therefore, is dependent on hypothetical premises which are not in keeping with the facts. It may therefore be disregarded in spite of the careful calibrations and painstaking calculations. The ascribed motion of the membrana basilaris in a definite phase of responses to stapedial movement is one possible manner of creating transverse movements at the auditory hairs. The transverse movement, however, is neither a theoretic necessity nor a demonstrable fact. There are other methods by which transverse movements at the hair cells might be produced if it is considered essential that such movements actually occur or are necessary. The answer to question V may be stated as follows:

The Wrightson hydraulic engine therefore becomes one with an elastic cylinder and many theoretical pistons, and therefore many hypothetically directed possibilities. The objections are, however, sustained and must be controverted before we can accept the Wrightson hypothesis. To us this hypothesis is nothing else than an ingenious interpretation of facts as they appear to Wrightson but not of the facts as they actually occur.

The curious mechanical relation of the middle ear to the inner ear calls for the solution of another problem to which we must now turn our attention. The problem is:

VI. In what manner does the Wrightson piston movement of the basilar membrane occur when the sound vibrations are transmitted through the temporal bone to the inner ear?

While Wrightson has considered this point in the presentation of his evidence, the chief exposition was left to Keith, whose explanations are quoted in extenso. These explanations occupy the two pages on the bone conduction of sound vibrations. "There remains one very important matter which

must be considered because of the light it throws on the mechanism of hearing. We have been regarding the stapes as the main agent in producing the fluid displacements which stimulate the organ of Corti. There are on record authentic cases of men and women who have been able to hear after the footplate of the stapes has become immovably fixed in the oval window. So long as the organ of Corti is intact and the round window flaccid, hearing is still possible. There is another allied condition. Patients who have become partially deaf from destruction of the drum of the ear have their hearing improved when a slight resistance, such as a pellet of cotton wool, is applied to the stapes. When the movements of the stapes are hindered hearing is improved. When sounds are conducted to the inner ear by means of the bones of the skull, in people with normal hearing, the volume of sound is markedly increased if the movement of the stapes or drum is hindered. I do not think these conditions have been yet explained."

"How are displacement volumes produced under direct bone conduction? The total capacity of the cavity of the inner ear of man I estimate to be approximately 200 cubic millimeters; 130 of these are contained in the main cavity, or vestibule and semicircular canals; 70 are contained in the passages of the cochlea. I presume that, were the thick, exceedingly dense and elastic bony walls of the inner ear completely closed, the fluid filling it would be subjected to a rise of pressure during the condensation phase of every sound wave; the pressure would fall in every rarefied phase. If the cavity, instead of being completely closed, had a flaccid window in it, then the rise and fall of pressure would be accompanied by a movement of that membrane. I presume that in the condensation phase of a sound wave a column will be displaced from the vestibule towards the round window; in the rarefied phase it will move back towards the vestibule. The basilar membrane will participate in all movements of the displacement column and give rise to stimulation of the hair cells. If, however, there are two windows in the inner ear, the oval one in the wall of the main chamber as well as the round window in the lower passage of the cochlea, part of the displacement column will escape by thrusting the stapes outwards; the part which thus escapes is ineffective, so far as the basilar membrane is

concerned. Fixation of the stapes prevents such an escape. We see, then, why hearing is improved, in cases of bone conduction, when the movement of the stapes is hindered. We also see how small must be the volume which gives an effective movement of the basilar membrane. We have thus in direct bone conduction a means of discovering the actual volumes required to produce effective movements of the basilar membrane. I am certain that von Helmholtz greatly overestimated their size. He supposed that the length of the ligaments which bind the footplate of the stapes to the oval window might be regarded as indicative of the excursional movements of the stapes. The lengths of these ligaments represent the limits of stapedial movements—the limits of the movements produced, not by the drum of the ear, but by the two muscles which act on the footplate of the stapes. The actual figures given by von Helmholtz for the inward movement of the footplate in a complete excursion were 56 to 73 mm. The main cavity of the inner ear contains 130 cubic mm. of fluid; how much is displaced when a sound wave of a known vibrational rate and amplitude passes through the temporal bone? If we knew that, we could estimate the actual displacements of the basilar membrane and the movements of the hair cells when such and such a note is sounded. I think it will be found that the effective stroke of the stapes is less than 25 mm. in even the loudest tones."

The sound pulse in advancing through the temporal bone is said to increase the perilymphatic pressure during its condensation phase and to decrease the perilymphatic pressure during its rarefaction phase. The displacement of the liquid will therefore take place at both windows, thrusting them outward into the tympanum. This will naturally decrease an excursion of the membrana basilaris. However, if the stapes is held fixed, then all displacement thrust, according to Wrightson, will pass through the basilar membrane. The increased membrane reaction might therefore account for the resulting condition of increased efficiency in appreciation of sound through bone transmission.

There is clearly something amiss in this conception, because the entire Wrightson hypothesis is based on an inelastic container as mentioned before. Unless we assume this inelastic-

ity in the container in reference to the power and frequency of sound vibrations, we cannot even consider the hypothesis at all. However, when the hypothesis is applied to hearing due to bone transmission, then the container (petrosum) at once becomes an elastic capsule, because the liquid-membrane filler is incompressible. So elastic, in fact, does the container become as to participate in the rarefactions and condensations produced by the minute and rapid sound vibrations. How the container may be regarded as inelastic in one part of this hypothesis and elastic in the other is not clear, to put it mildly. Nor is it intelligible why the liquid and membranes may be considered incompressible in one aspect of the problem and compressible under another, because the intralabyrinthine pressure varies with that of the venules.

Keith adds that if we knew "how much is displaced when a sound wave of known vibrational rate and amplitude passes through the temporal bone," "we could estimate the actual displacements of the basilar membrane and the movements of the hair cells." This statement gives the impression that we are dealing with scientific probabilities, when, as a matter of fact, we are dealing with physical impossibilities.

According to Keith, "Everyone who has studied the mechanism of hearing has presumed that the walls of the inner ear are rigid and closed excepting at the two fenestræ." He adds: "In that I think we are justified." In spite of this we are asked to believe that a diffuse vibration in the temporal bone may give rise to variations in perilymphatic pressure.

Our answer to question VI may be stated briefly: The piston action of the membrana basilaris cannot take place as a result of bone transmission. The evidence at hand does not disprove the point that sound is normally transmitted through the drum membrane and ossicular chain, even when the stem of the vibrating fork is applied to the vertex.

VII. Wherein does comparative anatomy show a confirmation of the Wrightson hypothesis?

The answer to this question is very simple and very brief. If one assumes that the membrana basilaris functions as a piston because of its position between the oval and round window, then comparative anatomy confirms this assumption with regard to amphibians, reptiles, birds and mammals. If we as-

sume that the membrana basilaris does not function in the manner described by Wrightson then the position of the basilar membrane determined in the amphibian holds for all the other vertebrates on the basis of structural pattern, and the acuity in hearing is in no way affected. However, in the case of the birds a very serious objection may be made. It is more serious than in the case of the mammals, because the tegmentum vasculosum, corresponding to Reissner's membrane, lies at the columellar footplate aspect of the basilar membrane and forms a delicate and highly vascular shield. Now if the blood vessels must be considered highly efficient regulators of perilymphatic pressure, as Bezold has suggested and Keith has all but admitted, then the directed pressure of the columellar thrust must pass through a very specialized absorber before it displaces the membrana basilaris at all, not to speak of the membrana tympani secundaria. Keith regards the tegmentum vasculosum as part of the liquid which fills the cavity. In the goose the secondary tympanic membrane is not even related to the tympanum but is applied to the vena jugularis. The goose therefore has but one opening—the fenestra vestibuli—applied to the tympanic cavity, and the pressure exerted by the air of the middle ear is not effective on the membrana tympani secundaria. The pressure displacement of the perilymph in this form must exceed that of the small blood vessels of the extensive tegmentum vasculosum before the membrana tympani secundaria may become operative in adjusting the mass displacements.

It is noteworthy that Keith in his appeal to comparative anatomy makes no mention of the pressure regulation factors in forms with a single muscle (amphibians and birds), although it was suggested that the antagonistic function of M. tensor tympani and M. stapedius in the mammal were related to this factor.

It is true that careful measurements and detailed histologic investigations have been made by Wrightson and by Keith on the relations of the membrana basilaris and the position of the organ of Corti, but this valuable material has no relation to the problem in hand: the Wrightson hypothesis. We, therefore, cannot agree with Keith when he says with reference to the birds "that the theory put forward by Sir Thomas Wright-

son, if it does not give us a full and complete clue to every item in its structure, serves this purpose to a much higher degree than any other I know of." We should rather say: The Wrightson hypothesis when applied to the birds does not work and fails utterly when applied to the goose, which is remarkable for its acute sense of hearing.

It would appear that the investigators following the mass displacements are not considering other possibilities. They accept as fact the sequence of events suggested by Helmholtz and therefore do not feel called upon to justify them.

Beyer[3], after a very complete study of the anatomy of the middle ear region in practically all vertebrate forms, makes very positive notations that the Helmholtz conception of a mass reaction in the ossicular chain cannot obtain. In particular, the leverage system reducing the amplitude of drum membrane vibrations meets with many serious objections. Forms in which the ankylosis of the malleus to incus and the ankylosis of the malleus to the annulus is the rule show no diminution in the acuity of hearing. The analysis of the anatomic relations of the incudomalleolar articulation by Frey[15 16] on complete serial sections of fifty-five species of mammals also substantiate this very point.

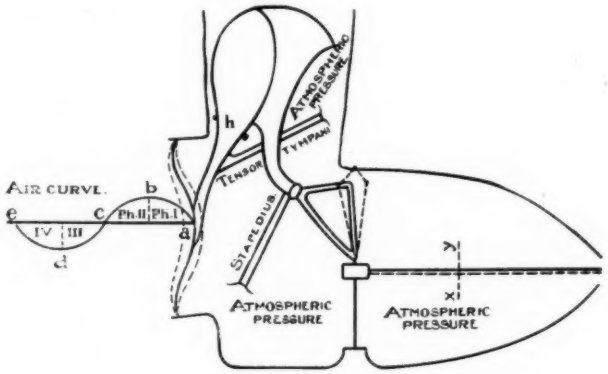

Figure 1.

II.

INTRANASAL RECONSTRUCTION.

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By reconstruction we mean the returning of the nose to as near its normal condition as possible, with the least amount of damage or destruction to its tissues.

The nose is the protector of our lungs by cleaning and modifying the air currents passing through it. Therefore, the size of the openings in the two sides should be as nearly equal as possible, with all the turbinates in place and the mucous membrane in normal condition, if we are to get the utmost use of these structures.

Opening into the nose are various sinuses: frontals, ethmoidals, sphenoidals and maxillary, which must have drainage and aeration, properly obtained only with a normal nose. The nasal passages are really the continuation of the eustachian tubes, and normal hearing is dependable more or less on a normal nose. In the past we did not fully realize the function of the nose; and still at the present time too much normal tissue is being removed which not only takes away our protection but leaves nonfunctioning scar tissue.

With a normal nose in mind and ever remembering its function, we examine to see if the air chambers are equal in size, and if not, what makes the difference. Is the septum straight, thin and in the center line, or is it bent to one side, or is it straight but thick between the middle turbinates, or has

"spurs" of various sizes? Are the turbinates hypertrophied or hyperplastic, stand out from their attachments, are bulbous or have hyperplastic ends and borders? Is either the septum or turbinates or both interfering with the drainage and aeration of the sinuses or the aeration of the eustachian tubes?

A deflected septum is to blame for most of the troubles in the nose. It is not only out of line itself, but also causes pressure atrophy of the turbinates on the one side; and nature, in trying to equalize the air currents, enlarges the turbinates on the opposite side, and with these bulgings, thickenings, hypertrophies and hyperplasias, the air is not properly filtered and modified and the drainage and aeration of the sinuses are interfered with.

SEPTUM.

In the reconstruction of the septum, the submucous resection operation only should be done. Cutting or sawing operations do not straighten the septum and leave large scar areas which have no secreting function. In a submucous resection the only damage to the mucous membrane should be a short, threadlike scar at the anterior nares on one side only. A complete submucous resection should be performed in every case. As much of the cartilage as possible is to be left; this supports the cartilaginous portion of the nasal bridge and prevents the flapping of the membrane when the nose is blown. The bony septum should be taken out high enough up to prevent tenting of the membrane and to allow it to hang not only straight but in the center line. The crest must be well taken out to prevent the tenting below. Too many operators, especially beginners, do not observe these points. Incomplete operations and the tenting above and below are to blame for failures. We hear of too many operators doing a submucous resection against time. I care not who the operator is or what his experience, he cannot do a complete operation and with the least damage to the flaps, when time only is considered.

The cartilage and bone between the middle turbinates must be well removed, as the air currents in breathing pass this point and the drainage of the frontal and anterior ethmoid sinuses is affected by it. In nasal troubles an apparently straight septum is generally thick and should be operated on for this rea-

son. If, at the time of the operation, both flaps are torn, a not too large perforation can be closed with a sliding flap. If this is not possible and the hole is opposite the lower turbinate, the turbinate can be used to close it. In nearly all old perforations, if not too large, the lower turbinate or portions of it can be used to close the hole.

After an operation, if a patient has a small perforation anterior which "whistles," more of the cartilage in front of the hole should be removed to make the septum straight. The whistle is due to the ballooning out of the membrane by unequal air currents. In some cases it may be necessary to enlarge the hole. A month or two after a submucous operation, if the patient is unable to breathe easily, the soft hypertrophies on the septum anterior to the ends of the middle turbinates are to blame and should be cauterized. If the membrane is lax and flutters when breathing, it can be tightened by cauterizing the thicker areas high up and back.

TURBINATES.

In reconstruction of the turbinates, none of the functioning part is to be removed. After a septum operation, if given time, nature will in nearly every case reconstruct the turbinates. The small ones will become large and the large ones small, owing to the air currents passing over them. Occasionally, it will be necessary to help nature. If they stand out too far they can be broken down, and if they are in too close they can be fractured out.

On the lower turbinates all hyperplastic posterior ends or lower borders are to be cut or snared off, but the bone is not to be injured. Occasionally it will be necessary to cauterize stripes through a persistently hypertrophied lower turbinate to reduce its size. Portions of the lower turbinate are not to be removed when operating for antrum disease; besides its other uses, it helps to protect the new opening from dirt and cold.

On the middle turbinate the hyperplastic posterior end and lower border is to be cut or snared off and the enlarged lobulus on the anterior end is to be removed. If the middle turbinate has a large bulbous or cystic end, the lateral half of the cystic wall is to be removed, it being lined on both sides with mucous

membrane. A thin turbinate is the result as soon as the wound heals.

In operating for frontal, ethmoidal or sphenoidal disease, care is taken not to remove any of the middle turbinate, all of the work being done under it. The cavity is treated until lined with healthy mucous membrane; the turbinate is then broken in to help fill the space if necessary.

So far reconstruction in atrophic catarrh is in the experimental stage. As the ethmoids are involved, these cells should be opened and made into one large cell with perfect drainage under the middle turbinate. As soon as the cavity is lined with mucous membrane most of the secretions and crusting will cease. If the septum is badly deflected a submucous resection should be performed to equalize the air space. The crusts are kept soft with oily lotions. The whole mucous membrane surface is stimulated with applications like iodin-glycerin, and a hand suction pump used every day for a few minutes to draw blood into the membranes.

Working along the line of endocrine disturbances we have been giving suprarenal gland tablets, 1 grain three times a day, over a long period of time. Not only the nasal but also the patient's general condition is improved. After the secretion is somewhat stopped and the membrane becomes thickened some building up can be tried like that suggested by Dr. Beck, using pieces of bone under the mucous membrane.

SUBMUCOUS RESECTION.

The patient is operated on in the semireclining position. He is then comfortable, does not faint, there is better control of his head, and the operator is working with his arms down in a natural position. Nature has wisely provided a coating to the mucous membrane of the nose and an immunity to the germs of the air; therefore, it is better to do very little cleaning before a submucous resection for fear of breaking up this immunity. The outside of the nose is cleaned with alcohol and the face is covered with a piece of gauze moistened in 1:5,000 mercuric chlorid solution. The hairs at the opening are cut to give a better view, and the inside of the vestibule is wiped with iodin followed by alcohol. Both sides are sprayed with a little cocain (4 per cent) and the nerves blocked by

the following method: The ends of four wooden applicators are slightly notched to prevent slipping and wound with a small piece of cotton. The cotton is then moistened with epinephrin (1:1,000) and applied to flaked cocain until it becomes saturated.

One applicator is placed as high up as possible on a line with the anterior end of the middle turbinate which blocks the anterior ethmoidal nerve; another is placed at the posterior end of the middle turbinate and blocks the sphenopalatine ganglion. This is repeated on the other side, as it is necessary to block the nerves on both sides of the septum.

A piece of cotton, saturated with epinephrin (1:1,000) is placed against the septum on each side to prevent bleeding during the operation. The patient is then given a hypodermic of ⅛ grain of morphin with 1/250 grain of atropin. This small dose does not make the patient "dopey," but it is large enough to cause relaxation and to take away fear; it also helps to prevent the after bone pain when the cocain wears out. In about twenty minutes the cotton and applicators are removed and the operation is performed without pain and, in most cases, with very little bleeding.

The nostril is held open with a Monosmith or right angle nasal speculum. The cut is made with a Freer septum knife on the convex side of the deflection; it is thus possible, as the membrane is elevated, to lift out the flap and so get around the bend without tearing it.

The cut is in the mucous membrane at its junction with the skin and extends from the top of the nose down to but not upon the floor, and goes through the mucous membrane and perichondrium to the cartilage. The membrane is then pushed back at the center of the cut with the edge of the knife until the white, shining cartilage shows. The membrane raises easily if the elevator is between the perichondrium and the cartilage, and with difficulty if between the perichondrium and the mucous membrane.

The membrane is then raised for a short distance with a small elevator; the right angle elevator is now used to elevate from the inside toward the cut, both above and below the original elevation. The original incision is now completed with the knife through the length of the membrane, cutting from

the inside out, both above and below. In starting the elevation this way it is possible to avoid cutting through the cartilage and the membrane on the other side if the original cut is extended down to the cartilage through its whole length. The membrane is now raised with a long blade elevator as far back and as low down as possible or, if there is a spur, to its sharp edge. The original cut is now extended to the floor; bleeding comes with this cut, and so it is made after most of the membrane is raised, to have a field clear of blood while starting the elevation.

The floor is then elevated with the small elevator; it starts with some difficulty, as the membrane is bound tight to the bone at this point. After the floor is elevated the membrane on the septum is raised from below to meet the elevation from above or, if a spur is present, to elevate the under side up to and freeing its sharp edge.

In many cases it will be necessary to use a knife to cut the strong adhesions between the membrane and the bony septum where the crest of the superior maxilla joins the cartilage and the perpendicular plate of the ethmoid, as the fibers of the perichondrium and periosteum cross here.

After the membrane is completely raised it extends from the top of the nose out on the floor like the side of a tent.

The cartilage is incised with a Freer original septum knife just inside the original cut at an oblique angle, which brings it through at a slant just under the perichondrium on the other side. As much of the mucous membrane as possible is raised on this side, being sure to elevate well down on the floor in front with the right angle elevator, as this is the place where the chisel will enter later.

The Foster-Ballenger speculum is now inserted and holds the flaps of mucous membrane away from the cartilage and bony septum. The flaps are then inspected to see if they are entirely free.

After the flaps are elevated a small slice about one-eighth inch wide is taken off the cartilage along the inner edge of the cut. This is to prevent exposure of the cartilage if the flaps retract in healing. To avoid the dropping of the cartilaginous bridge and give it support we leave in place as large a piece of cartilage as possible, the thickness and deflection determining

the size. A nick is made in the cartilage with the scissors as low down as necessary to retain the piece of cartilage desired. The Ballenger swivel knife, starting in this cut, is carried in and up with a half curve, then in, then down and then out, following the cartilaginous bony union. This cut piece of cartilage is now removed. The piece of cartilage left is easily pushed over by the speculum against the flap until the operation is completed.

After the cartilage has been removed a better view is afforded to determine if the flaps are fully free. Before closing the flaps, if the piece of cartilage left causes a tent, start in the deeper part of the nose and cut this piece toward the tip of the nose until it hangs straight, never entirely cutting it off. This heals between the flaps and gives support where it is most needed and helps prevent flapping when the nose is blown.

With Jansen-Struyken forceps cuts are made in the bony septum along the crest, also high up under the ridge; then with a pair of duckbill forceps this piece is broken out. These cuts should always be made; they not only allow the bony septum to be easily removed but, most important, prevent the possible fracture of the cribriform plate. Duckbill forceps are then used to take out the rest of the bony septum back to the sphenoid; being sure the septum is well removed between the middle turbinates, this being the most important region in the nose.

We now have the bony crest remaining. Along its upper edge is a strip of thick cartilage, the remains of the cartilaginous septum or the cartilaginous edge of a spur, which is removed with the right angle elevator.

Elevation of the membrane on the other side of the crest can now be effected by starting the right angled elevator deep in the nose and drawing it toward the tip between the crest and periosteum. The flaps being free, a V-shaped chisel is placed at the anterior edge of the crest, and with one or two sharp taps of a hammer the front and thick part is broken off. The rest of the crest is then removed, either with the chisel or the duckbill forceps.

The inside of the flaps are swabbed with 1:5,000 mercuric bichlorid to prevent infection and thoroughly dried out. The

speculum is now removed and the flaps are brought together and inspected to see if they hang straight and that no ridges or spurs are left.

One suture is used in front to hold the edges of the flaps together. An Allen self-retaining speculum is inserted, the flap is held with a pair of small Hartmann forceps, and a small eye needle carrying a silk suture passed through it; then the needle is passed in the opposite direction through the membrane at the anterior edge of the cut. The suture is then tied, bringing the edges of the flaps together. This makes a figure 8 of the suture, but is the easiest tie to make. In a few days it is removed.

The outside of both flaps and the turbinates are swabbed with 1:5,000 mercuric bichlorid to prevent infection.

Plates of dental wax as wide as possible are placed on each side of the septum to support the membrane. These are left in two days to prevent the patient from blowing the nose and disturbing the flaps. No other packing is necessary.

After the wax is removed the nose is cleaned and the patient instructed to use a nasal oil two or three times a day until the swelling in the flaps is gone.

COMPLICATIONS.

Sometimes a hematoma forms between the flaps and it will be neecssary to cut the most dependent portion to let out the blood, and occasionally the piece of cartilage left will slough and an opening must be made to let out this soft material.

In all infections an injection of diphtheria antitoxin (3,000 to 5,000 units) should be given at once, as they respond quickly to this treatment. Antitoxin is used because it is easily obtained at any drug store and furnishes the foreign protein which increases the phagocytosis. In some cases a thick meaty membrane forms on the septum and turbinates; it is not diphtheria but responds to the antitoxin.

The flaps in infected cases are always thick and the patient uncomfortable because of the breathing. Steaming the nose gives the most relief.

Tears in the mucous membrane and thin spots from ulceration are smeared with an ointment of scarlet red (10 per cent); these places heal nicely under this treatment.

Soft hypertrophies on the posterior ends of the lower turbinates should be removed at this time; also any polyps coming from the ethmoids.

The middle turbinates are to be broken over to give better drainage if the patient is having sinus trouble.

If, after the operation is completed and there is a tear through both flaps, not too large a hole can be closed by the following method: A cut is made through the larger flap as high up as possible and extending as long as necessary to allow this flap to drop or fold down, covering the tear in the other flap. If the original flap is used it must be left attached in front, and must have as much membrane as possible over the tear; just barely covering it will not do, as mucous membrane flaps always retract.

Nearly all the perforation during submucous resection are due to sharp angular spurs, which occur most frequently at the upper end of the crest. If this occurs opposite the lower turbinate, and the flap method is not sufficient, the larger turbinate opposite the tear should be scarified and the septum placed over against it. A plate of dental wax is placed against the septum on the opposite side, the packing outside this; it is thus possible to change the packing every other day without disturbing the wound. In about a week it will become adherent, and as soon as the adhesion is firm a piece of the mucous membrane of the turbinate is cut out, closing the hole.

In cases of old perforations following a submucous resection, the technic is the same, except that the edges of the hole must also be scarified, and, if necessary, the turbinate can be partially detached and brought out to meet the septum.

About a month or two after the operation, if the patient is still unable to breathe easily, the soft hypertrophies on the septum are to blame. If these are deeply cauterized a roomy nose is the result as soon as the burn heals. But one side is to be cauterized at a time. If the membrane is lax and flutters when breathing, it can be tightened by cauterizing the thicker areas high up and back.

INTRANASAL EXENTERATION OF THE ETHMOIDS.

To do an exenteration of the ethmoids under the middle turbinate and conserve the turbinate, it is necessary to have a

space of 5 mm. when the tissues are thoroughly contracted. If this space is not available a submucous resection of the septum should be performed. Polypi, lobuli and soft hyperplasias of the anterior ends of the middle turbinates that the snare can engage should be removed. If there is a cystic middle turbinate present the operation for the cystic middle turbinate should be performed before the exenteration.

There are two anatomic points that should be kept in mind:

First, we can roughly measure to the posterior wall of the sphenoid by marking a line on the temple, half way between the temporoorbital edge and the bony auditory orifice. This point marks the posterior wall of the sphenoid. With this known point and knowing the average anteroposterior measurements of the ethmoids and sphenoid, we can by internal and external measurements during the operation easily tell just where we are in these important structures.

Second, the inner canthus of the eye is on a level with the cribriform plate and is also the position of the internal orbital plate; so this external point can be used to judge the direction when breaking into the anterior ethmoid.

The instruments necessary for the operation are a nasal speculum and a pair of nasal cutting forceps (Gruenwald, Myles, Hartmann), with a fenestrated blade 5 mm. wide, which is about one-half the width of a normal ethmoid capsule. I find the forceps with the universal handle the best, because the lower lip of the blade is stationary, and the blade can be placed just where it is wished to cut, and there is no pulling back in the action. Another instrument needed is a Pratt double end cup-shaped curet, 22 cm. long, with one end bent at an angle of 45 degrees, about 2 cm. from the end, the cup in the angle end to be fenestrated. The cup on the straight end should be 1 mm. shallower than the angle end, which gives it a sharper point to more easily open into the ethmoid when necessary.

The same anesthesia (blocking of the anterior ethmoid nerve and the sphenopalatine ganglion) is used as in the submucous resection of the septum, only blocking the side to be operated.

With the patient in a sitting position and the head thrown well back, the anterior attachment of the middle turbinate is just below the visual line to the internal canthus. The open

cutting forceps is placed under the middle turbinate with the upper blade just under the anterior attachment and pressure made on a line with the internal canthus, breaking into the anterior ethmoid cells, biting backward and upward as long as there is any soft bone encountered.

As we progress backward for a complete exenteration the head is brought forward so we can follow along the plate of the skull. With a mental picture of the ethmoid capsule, bounded as it is on the orbital side by the lacrimal bone and the ethmoid orbital plate, nasally by the middle turbinate, superiorly by the temporoorbital plate and posteriorly by three-fifths of the anterior wall of the sphenoidal sinus, we take the straight end of the curet and with a firm but gentle stroke in every direction curet out all the soft tissue. If we find firm, smooth and yielding tissue under our curet on the orbital side we know we are down to the periosteum of the orbit and force should not be used.

The anterior cells are removed with the angle end of the curet, curetting in an arc form toward the tip of the nose, thus removing the anterior cells and enlarging the space upward toward the frontal sinus. We now cut out the floor of the capsule back to the sphenoid sinus, giving a free drainage under the entire length of the middle turbinate. There is little bleeding, owing to the fact that we do not cut either the anterior or posterior ethmoid or the sphenopalatine arteries.

The cavity is wiped out with large swabs, using a whirling movement to collect any particles of bone and débris, and then a large swab of cotton saturated with an iodin and glycerin solution is applied in the cavity for a few minutes to stop the bleeding and disinfect it. With a dry cavity any overlooked soft portions can be removed.

The cavity under the turbinate is not packed, but a finger-shaped piece of cotton is placed in the middle meatus back to the anterior end of the middle turbinate, and the patient is allowed to go home, with instructions to remove the cotton in four hours and report in three days. The home treatment consists of dropping a few drops of nasal oil into the nostrils three times a day, the patient in the supine position with the head back; as the medicine is dropped into the nostril, he is told to sniff violently. Every third day, after cocainizing and

cleaning the nose, the cavity under the middle turbinate is swabbed with the iodin-glycerin solution. It will frequently be found necessary to bite away granulations to keep the cavity clear and healing properly. In a short time it is hard to detect that the nose has been operated upon.

If, after a suitable length of time, the discharge does not cease, the nose can be recocainized and the operation easily extended into the frontal, sphenoid or any adjacent cells that may have been overlooked.

INTRANASAL FRONTAL SINUS OPERATION.

We are becoming more convinced that it is seldom necessary to do a radical frontal sinus operation or an intraexternal operation like the Lothrop.

Unless the symptoms show a brain involvement, we believe that, if the natural ostium is enlarged enough to give free drainage, and the discharge removed by suction if necessary, this treatment will show the greatest percentage of recoveries. It is extremely simple after the anterior ethmoids have been exenterated by the "under the middle turbinate method" to enlarge the frontal sinus opening with the rasps, as recommended by Dr. Good years ago. The lateral space available for an intranasal opening into the frontal sinus is from 5 to 7 mm. This is a little less than the width of the articulation of the ethmoid bone with the frontal. A workable outline shown on the patient is the space between the internal canthus and the central perpendicular line of the nose.

OPERATION.

Instruments: Nasal speculum, Gruenwald biting forceps No. 3, Pratt double end ethmoid curet, frontal applicators, Good-Thompson rasp set.

Anesthesia: Blocking of the anterior ethmoid nerve and sphenopalatine ganglion, following the ethmoid exenteration with applications of cocain on curved applicators to the frontal sinus duct region.

The cutting forceps is placed open just under the anterior attachment of the middle turbinate. With the tip of the movable blade pointing toward the internal canthus, pressure in this direction will break into the anterior ethmoid cells.

The cells are bitten away to the frontal plate and backward as far as the posterior wall of the anterior ethmoid, which is recognized in nearly every case by the firmer partition. This space is smoothed by the straight end of the curet. The angled end of the curet is now inserted with the cup pointed forward, and curetting motions are made in an arc form toward the tip of the nose. The smooth, firm bone will be recognized as soon as all cells have been broken down and removed. Bleeding can be stopped, if necessary, by swabs dipped in the iodin-glycerin solution, or epinephrin chlorid. With beginners it is well to attempt passage of the frontal probe of the rasp set, and if successful the little groove on the rasp placed on the probe gives the correct direction for the point of the rasp. After a few trials the rasp is used directly without the use of the probe.

To find the frontal opening, take the sharper curved rasp and pass it under the attachment of the middle turbinate into the exenterated space of the anterior ethmoid. Point the tip of the instrument toward the frontal sinus in an imaginary space marked by a central perpendicular line with a parallel line passing through the internal canthus. By working delicately upward with a rasp motion in this direction you will either find the normal opening or break through intervening cells into the frontal sinus. The rasp cuts on the pull, so the opening is enlarged accordingly. The opening should be large enough to pass with ease a 3 mm. cannula. This size is maintained by using frontal dilators until the case is cured. If granulations form or the hole contracts, the rasp is used again.

OPERATION ON THE CYSTIC MIDDLE TURBINATE.

The nasal speculum, cutting forceps and snare are the instruments usually needed in this operation.

The cystic middle turbinate generally has a lobular deformity, which when snared off opens the cyst. If there is no deformity, but simply a large turbinate, the cutting forceps will, as a rule, easily break into the cyst; but should it be too dense some sharper instrument, such as a chisel, will make a point of entry for the cutting forceps. The point of entry should be in the lateral half of the anterior end. It will be seen on opening that the lateral wall of the cyst is extremely thin and

should be bitten away, leaving the heavier mesial wall to become the future turbinate. As the cyst is lined by mucous membrane, the turbinate is soon well and completely covered. It is surprising how soon it will thicken and return to form.

If the ethmoid is diseased the exenteration of the ethmoid is continued at this point; otherwise the turbinate is broken toward the lateral wall and packed in this position. The packing is removed in two days and reapplied if necessary.

ANTRUM OPERATION.

A semiradical antrum operation easily performed is as follows: The parts are anesthetized by blocking the anterior ethmoid nerve and the sphenopalatine ganglion as in the submucous operation and placing a swab under the lower turbinate. It is best to wait at least twenty minutes.

The anterior attachment of the lower turbinate is cut far enough to allow the turbinate to be displaced upward, giving a good view of the lateral wall underneath.

With the small curved chisel an opening is made into the antrum about one-half inch posterior to the anterior attachment of the lower turbinate, and the chisel turned to make a round opening. The Good-Thompson frontal rasp is now used and the lateral wall anterior to the chisel hole is rasped away, exposing the anterior angle of the antrum. The Gruenwald cutting forceps are now adjusted so as to give a horizontal cut. They are introduced closed into the nostril and, when allowed to open, the active blade will slip into the opening made by the rasp and the lateral wall posteriorly is removed as far back as necessary.

The antrum can now be curetted by angular curets and allowed to remain open. The turbinate is now replaced. The biting forceps can be used at any time to remove granulations to keep the opening free.

HYPERTROPHIES AND HYPERPLASIAS.

We find in our work that simple hypertrophies of the nose, when caused by a deflected septum or sinusitis, will gradually recede when proper ventilation is restored and the sinusitis cured. When this hypertrophy has progressed to hyperplasia

we find it necessary to remove certain portions until the turbinates conform to the normal.

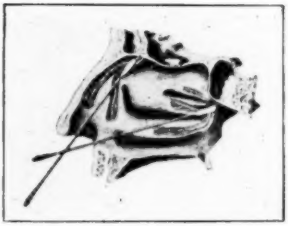
We believe that this work should not be hurried or too much removed at one sitting. The rapidity of covering the denuded portion with healthy mucous membrane is hastened by limiting the amount of destruction. It is necessary to always keep in mind the relative size of the normal structure that occupies the space, to avoid removing any portion necessary to its proper restoration.

The soft, irregular hyperplasias, whether situated on the anterior or posterior ends or hanging from any other portion of the turbinates, can be easily removed with the snare.

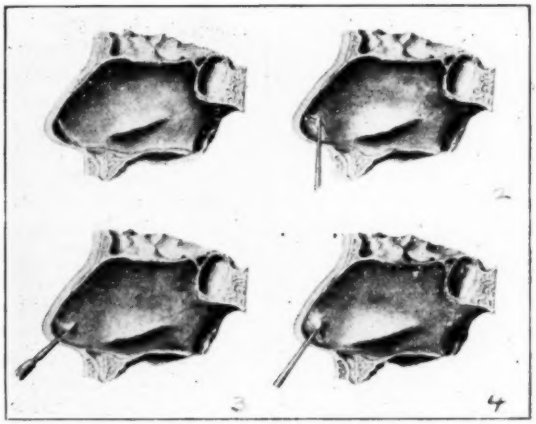
By using the snare we are not removing any undue amount of tissue. When the snare cannot be used the biting forceps can be employed under inspection and the turbinate trimmed to normal contour.

919 Metropolitan Bank Building.

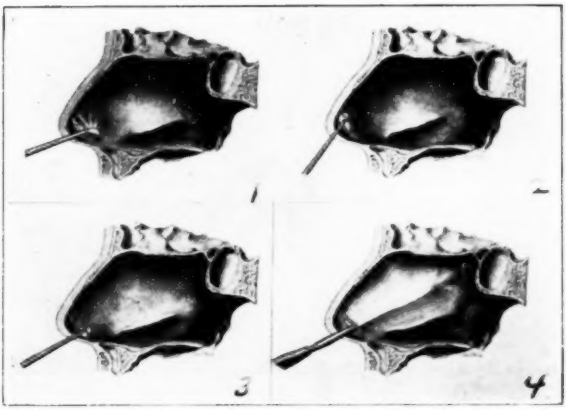
Position of patient during operation.



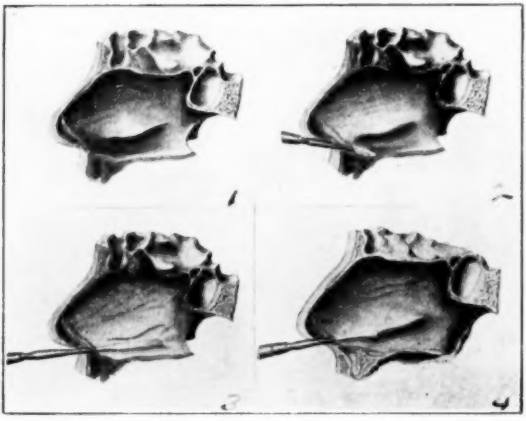
Cotton applicators blocking anterior ethmoidal nerve and nerves from spheno-palatatine ganglion.



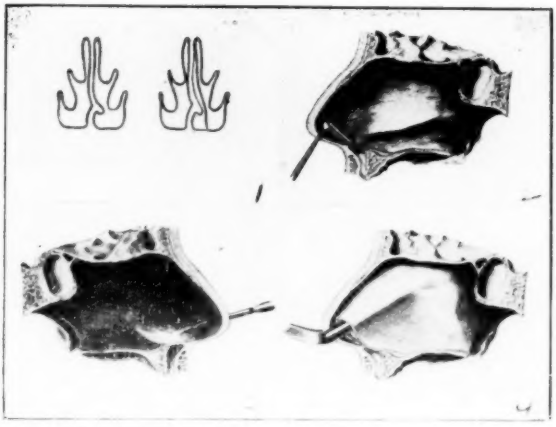
1. Cut through mucous membrane and perichondrium.
2. Pushing membrane back over the cartilage.



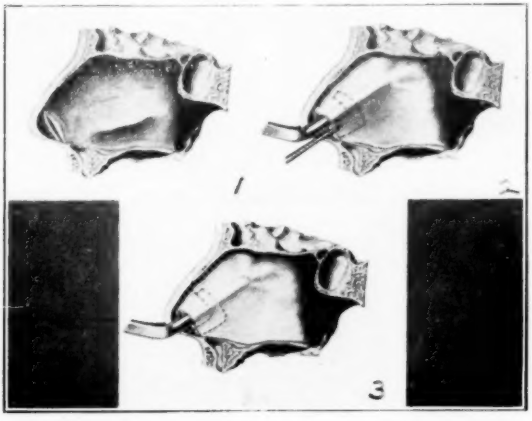
1. Elevating lower part of flap near cut from the inside.
2. Completing original cut from inside out at upper end.
3. Completing original cut from inside out at lower end.
4. Elevating flap above spur.



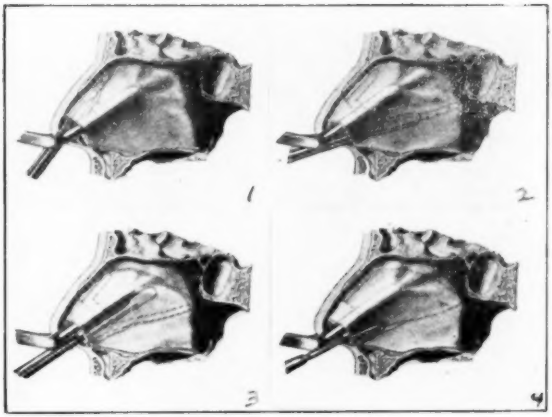
1. Completing original cut down on the floor.
2. Elevating membrane on the floor.
3. Elevating membrane on the under side of spur.
4. Elevating membrane on the edge of spur.



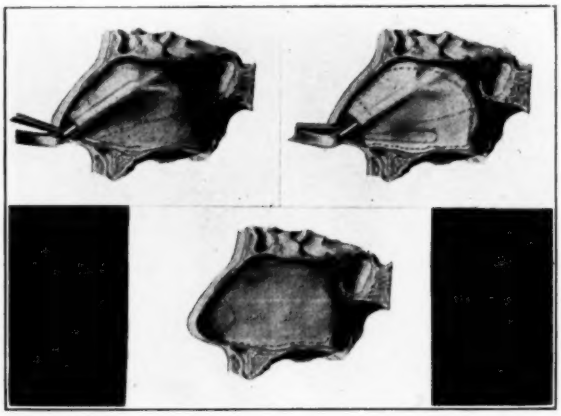
1. Shows flap elevated on one side out on floor.
2. Cut through the cartilage.
3. Elevating the membrane on the opposite side well down on the floor in front.
4. Speculum holding flaps apart.



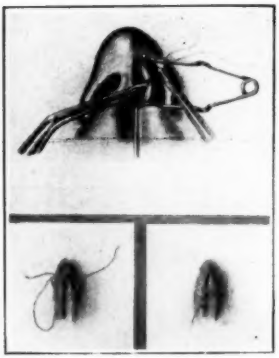
1. **Small slice taken off cartilage at the original cut.**
2. **Piece of cartilage taken out by Ballenger knife.**
3. **Cut at posterior edge of cartilage.**



1. Struycken's forceps making cuts in bone below.
2. Struycken's forceps making cuts in bone above.
3. Bone being removed by duck bill forceps.
4. Remains of cartilage along the crest removed.



1. Anterior part of crest broken by chisel.
2. The remainder of crest removed by duck bill forceps.
3. Shows amount of cartilage and bone removed.



Method of placing suture.

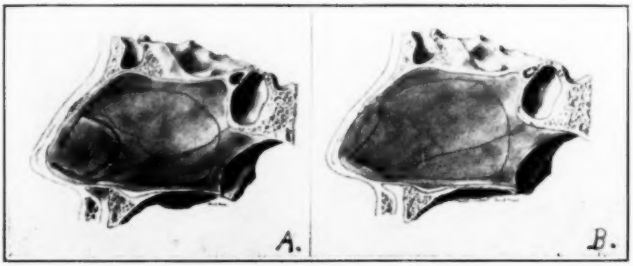


Fig. 13.—Submucous operation: A, largest piece of cartilage left, also cut if necessary to make it hang straight. B, smallest piece of cartilage and cut if necessary.

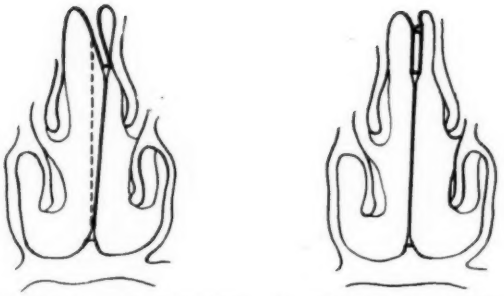


Fig. 14.—Submucous operation: A, tenting of membrane if bent cartilage is left; B, cut in cartilage to make it hang straight.

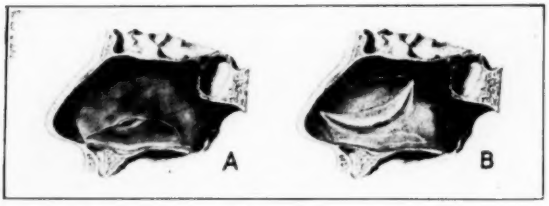


Fig. 10.—Submucous operation: A, flap with tear on one side, perforation in the other; B, sliding flap to close perforation.

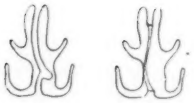


Fig. 11.—Submucous operation: Using lower turbinate to close perforation.

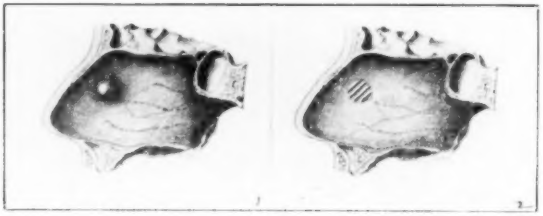


Fig. 12.—Submucous operation: A, soft hypertrophy on septum; B, cautery marks in soft hypertrophy.

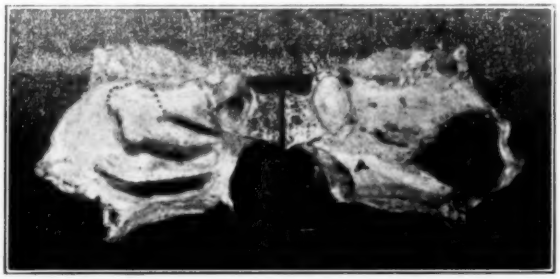


Fig. 1.—Ethmoid operation: Lateral wall of nasal cavity. The attachment of the so-called middle turbinate is outlined. The anterior ethmoid cells are covered by the anterior half of the middle turbinate. The posterior ethmoid cells are covered by the so-called superior turbinate.

A horizontal cut through the ethmoid capsule just below the cribriform plate, showing the bony walls of the capsule, and how the ethmod cells and sphenoids follow each in sequence anterio-posteriorly.

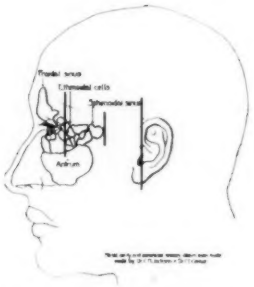


Fig. A—Ethmoid operation: Lateral view of the head, showing the relative position of the paranasal sinuses. Three perpendicular lines mark the orbit edge, the bony auditory canal and the posterior wall of the sphenoid sinus.

Fig. B.—The three points marked by perpendicular lines shown on the skull.

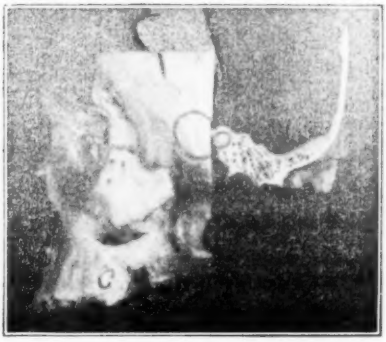


Fig. C.—The skull cut through at the middle perpendicular line, showing that it marks the posterior wall of the sphenoid sinus.

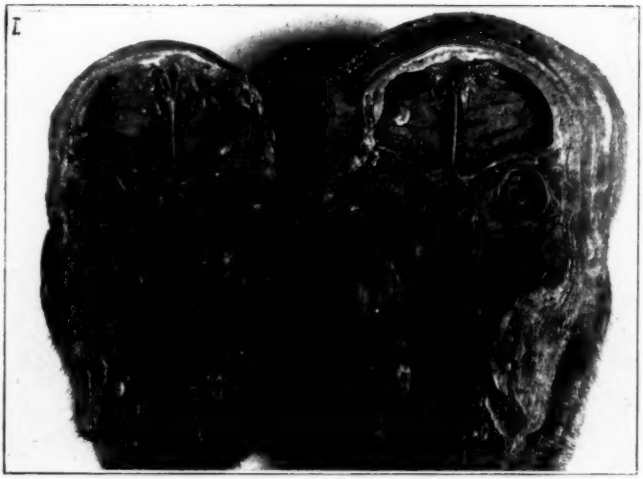


Fig. 1.—Transverse section of the head just posterior to the anterior attachment of the middle turbinate.

A. Showing the over hang of the turbinates.

B. Cystic condition of the middle turbinate.

C. In going up under the anterior end of the middle turbinate the anterior ethmoid cells are immediately entered.

D. How the nose portion of the floor of the frontal sinus is formed by the ethmoid cells.

Fig. 2.—Transverse section of the head, one c.m. posterior to the previous section.

A. The bony walls of the ethmoid capsule.

B. The cribriform plate on a level with the center of the eye balls.

C. Infundibulum.

D. Antro-ethmoidal cell.

E. The thin partition between the antrum and lower meatus, and the ease of operating at this point without destroying any part of the lower turbinate.

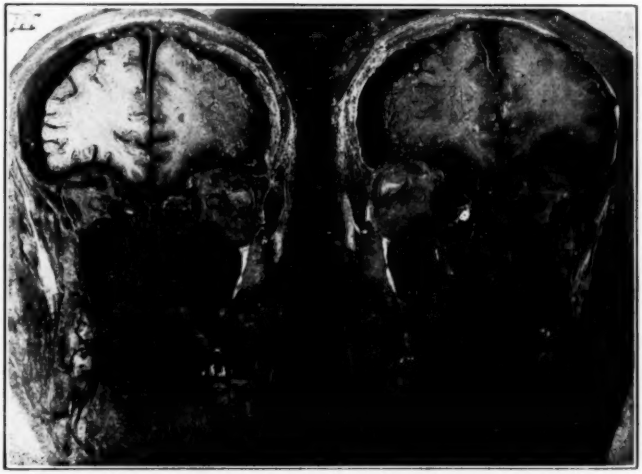


Fig. 3.—Transverse section of the head, one c.m. posterior to section II.

A. The continued bony walls of the ethmoid capsule.

B. The anterior walls of the posterior ethmoids.

C. The greater size of the posterior ethmoids.

D. How the posterior ethmoids are directly posterior to the anterior ethmoids.

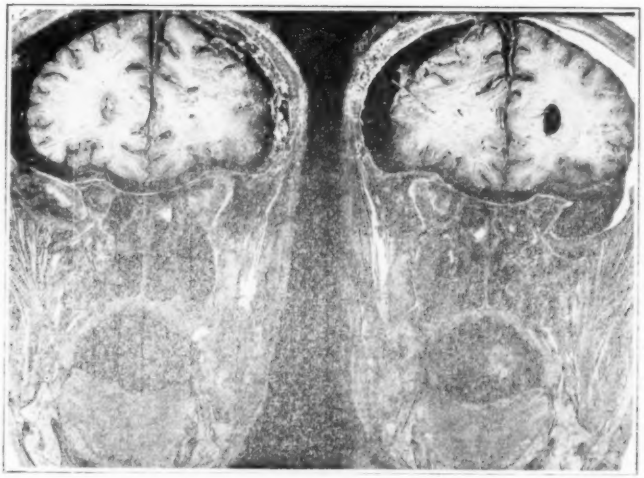


Fig. 4.—Transverse section of the head, one c.m. posterior to section III.

A. The posterior wall of the posterior ethmoid cells.

B. The ostia of the sphenoids.

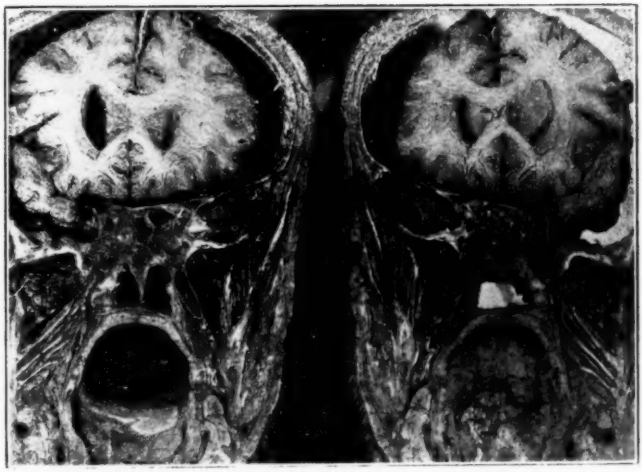


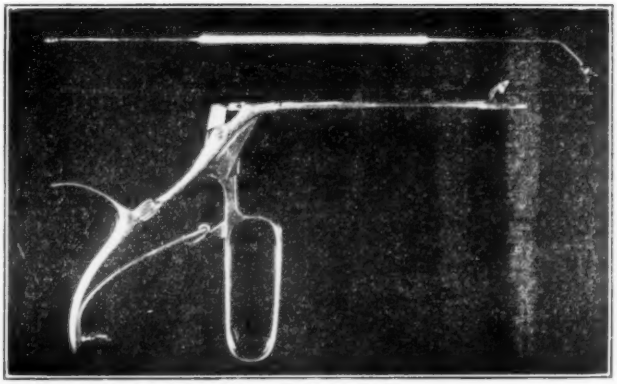
Fig. 5.—Transverse section of the head, one c.m. posterior to section IV.

A. Posterior wall of the sphenoids.

B. The large posterior ethmoid cells on the right in direct contact with the right optic nerve.

C. The membrane covering the posterior wall of the left sphenoid sinus is intact.

D. The small size of the sphenoid sinuses.



Ethmoid Operation.

1. The Pratt ethmoid curet.
2. The Gruenwald cutting forceps.

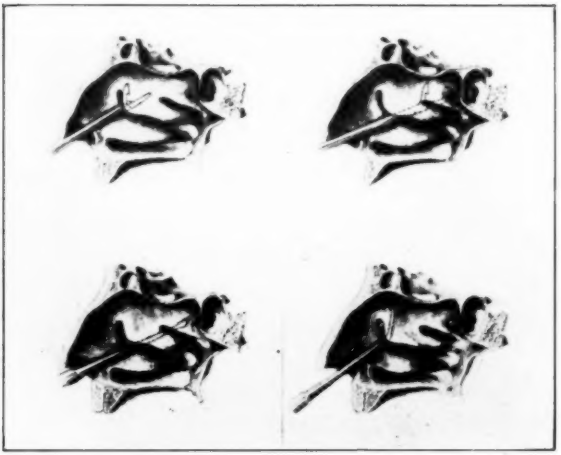


Fig. 3.—Ethmoid operation: A, Gruenwald forceps biting out the anterior ethmoid cells under the middle turbinate; B, the biting continued backward into the posterior ethmoid cells; as the partition walls of the cells are broken, the mesial wall of the capsule springs toward the septum, giving a large working space; C, curetting the cavity smooth with the straight end of the curet; D, removing the anterior and infundibular cells from the nasal floor of the frontal sinus.

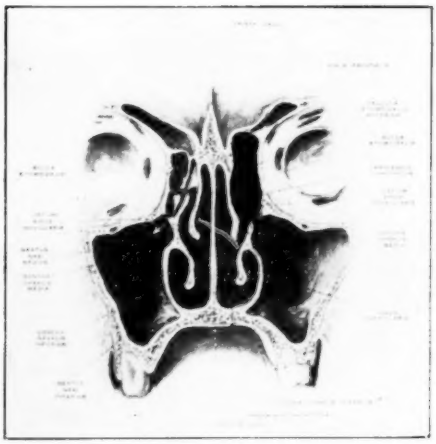


Fig. 4.—Ethmoid operation: Exenterated ethmoid region. The protection afforded by leaving the middle turbinate from injuring olfactory fissure or cribiform plate. The bony wall outlining the ethmoid capsule. This illustration is modified from a cut in Loeb's Operative Surgery of the Nose, Throat and Ear.

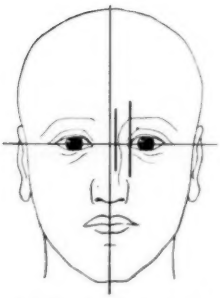


Fig. 5.—Intranasal frontal sinus operation: The central perpendicular line marks the septum. The horizontal line marks the position of the cribiform plate. Between the heavy and light perpendicular lines lies the olfactory fissure. Between the heavy perpendicular lines lies the ethmoid capsule; direction the instrument is to take to enter the frontal sinus intranasally.

Fig. 6.—Intranasal frontal sinus operation: Rasp under the middle turbinate into the frontal sinus after exenteration of the anterior ethmoids.

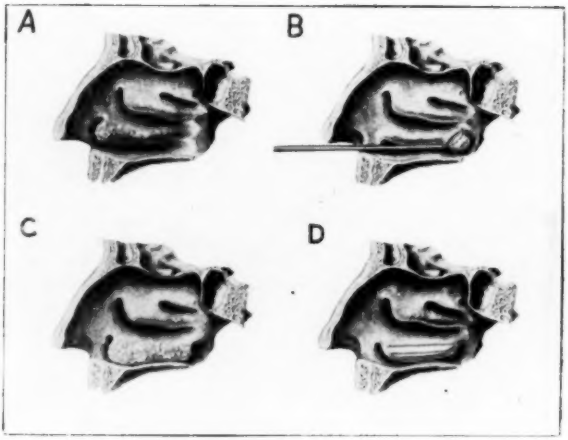
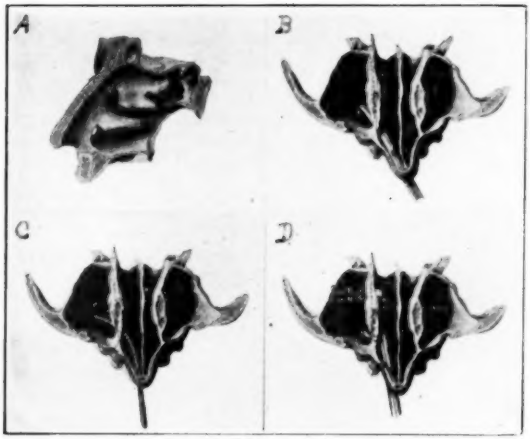


Fig. 7.—Operation for hyperplasias: A, hyperplasia of anterior end of lower turbinate removed by snare; B, removal of the hypertrophied posterior end of the lower turbinate with the snare; C, hyperplastic lower turbinate reduced by gradual snaring and cure of sinus diseases; D, hypertrophied lower turbinate reduced by cautery.



A. A three-fourths view of the lateral wall showing the anterior attachment of the lower turbinate detached and the turbinate bent upward, exposing the antrum wall.

B. The antrum wall under the lower turbinate punctured by the chisel.

C. The rasp in position to remove the anterior portion of the wall.

D. The biting forceps in position to bite away the wall posteriorly as far as desired.

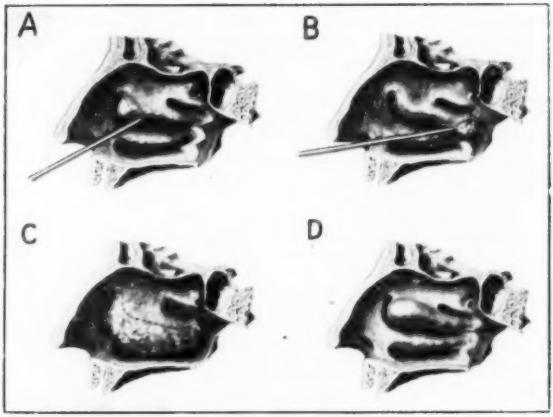


Fig. 8.—Operations for lobulus and hyperplasias: A, removal of lobulus with snare; B, removal of posterior hyperplasia of middle turbinate with snare; C, hyperplasia of middle turbinate complicated by hyperplastic ethmoiditis and adhesions to septum; reduced to normal by exenteration of ethmoid cells and gradually snaring away the hyperplastic tissue; D, cystic middle turbinate reduced as in Figure 9.

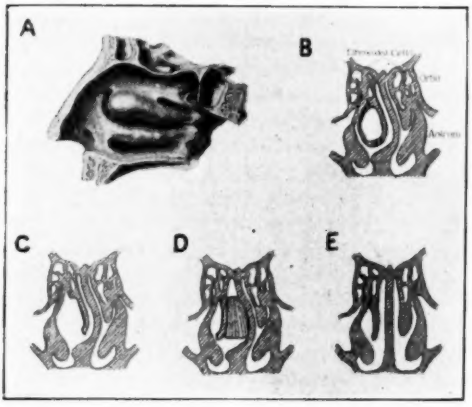


Fig. 9.—Cystic middle turbinate operation: A, cystic middle turbinate; B, transverse section showing cyst exposed and points where biting forceps start to remove the lateral wall; C, lateral wall removed; D, remaining portion of turbinate broken over and held in place by Simpson splint; E, submucous resection performed to remove septal deformity.

III.

GRAVITY DRAINAGE AND SWABS VS. IRRIGATION AND WICKS IN OTITIS MEDIA.

By George E. Barnes, B. A., M. D.,

Herkimer, N. Y.

Acute suppuration in the recesses of the middle ear, especially in patients with little resistance on account of bad general health, certainly presents difficult problems in treatment.

Irrigations wash pus out of the external auditory meatus and, through the incision in the membrana tympani, to some extent out of the middle ear, but the current of fluid certainly carries infective material from the meatus into the middle ear. Such a procedure cannot be said to be based on good surgical principle, and solutions of strong antiseptics cannot be used in the ear. Indeed, the avoidance of superinfection and reinfection of the middle ear is one of the cardinal points which should be observed in treating middle ear disease. Such added infection takes place with remarkable facility. It is a wonder that suppuration ever disappears under treatment by irrigations. Furthermore, as is well known, irrigations alone often fail to dislodge all the purulent accumulation in the meatus.

Does the gauze wick placed in contact with the incision in the membrane drain the pus out of the middle ear and along the meatus in an acceptable manner? Certainly not. It is well known in general surgery that gauze drains in the presence of pus do not drain but act as plugs. They very quickly lose their capillary action because the mashes become filled with pus, which, unlike thinner fluids, as volatile oils and water, is too thick to flow along gauze. This is especially true when air has access to the wick and dries the pus in the meshes. To be sure, this drying of pus in the meatal wick is considerably prevented by the wad of cotton in the concha which cuts off repeated access of air.

Now, if the prevailing treatment of otitis media by irrigations or wicks or the combined use of both is not based on good surgical principles, is it possible to improve on these

methods? Yes, by making use of gravity drainage, absorbent pads in the concha, and meatal cleansing by means of swabs, while the lips of the incision are kept from adhering by use of my spatula.

For good gravity drainage the patient should lie about half or more of the time with the affected ear on the pillow (which should be covered with a towel to catch any little pus that may leak out). Nearly all pus is carried outward along the meatus and is taken up by a rather loose wad of absorbent cotton placed in and filling the concha. This pad of cotton should be changed whenever it becomes saturated on its inner surface, and this is not much oftener than irrigations are practiced by those who believe in them. The concha should be washed with soap and water once or twice daily.

Every day or every other day the doctor should very gently swab out the meatus with a cotton wrapped applicator. This little procedure should be done with the utmost care. The applicator should be made of copper wire of about .03 inch diameter and of just sufficient hardness to prevent twisting while the cotton is being rolled on it. Such an applicator has sufficient resilient flexibility so that even when a trifle more pressure is made with it than intended it will bend easily and thus not cause, when correctly dressed with cotton, pain to the patient or injury to the tissues. I could not find such applicators on the market and had some made to order. (The ends of these applicators should be triangular in cross section so as to hold the cotton as the applicator is rotated.) Before using, the end of the applicator should be slightly bent to correspond with the curve of the inferoanterior wall of the meatus so that pus can be easily gathered up from the deepest recesses.

The flat pledgets of cotton which are to be rolled on the applicator should be carefully prepared. Of course, the hands should be thoroughly cleaned before the cotton is touched, and during the whole seance nothing should contaminate the ends of the thumb and index finger used in rolling the pledgets on the applicator. A thin layer is peeled off from a small handful of cotton, and from it are pulled flat pledgets of a size found to make a swab of just the right size to pass readily through the meatus without friction and to gather up the maximum quantity of pus. The pledget should not be too thin on the end

that is to form the business part of the swab, and if thus thin when first pulled off it can be folded back a little. The pledget should be rolled on the applicator only so tightly as to prevent it from coming off during use and to permit ready removal after use. It should be rolled quite tightly about the extremity of the applicator, but the cotton beyond the extremity should form a spongy tuft. This preparation of the swab protects the end of the applicator from injuring the tissues and hurting the patient and furnishes a good absorbent body.

A good method of procedure is first to remove with tissue forceps the pad of cotton in the concha and cleanse the concha; next to cleanse the outer half of the meatus with dry swabs and then with a swab wet with a strong solution of boric acid; and lastly, to cleanse the inner half of the meatus in the same manner, the whole meatus being finally swabbed with boric acid solution and partially dried. Care should be exercised not to make any or but slight pressure against the membrane.

If on inspection the edges of the incision in the membrane are found to be adherent in places and the membrane is still bulging and pulsating considerably, my spatula is gently inserted merely the depth of the incision and passed from one end to the other, avoiding any unnecessary spreading of the lips to prevent the entrance of fresh infection and disturbance of anatomic parts. The use of the spatula promotes drainage and prevents the closure of the incision except necessarily as it grows up at the ends. (Of course, the spatula may be used with the irrigation treatment if ever needed, but usually the force of the stream is apt to open the incision even too widely.)

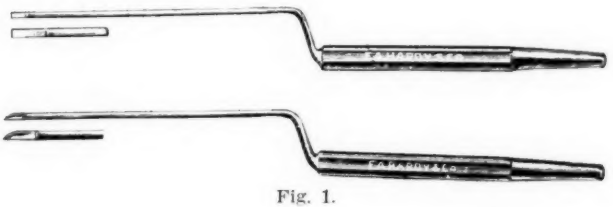


Fig. 1.

IV.

TONSILLAR TUBERCLES CONTAINING INTRACELLULAR CONCRETIONS SIMULATING FOREIGN BODY PSEUDOTUBERCLES.*

By Carl Vernon Weller, M. S., M. D.,

Associate Professor of Pathology, University of Michigan, Ann Arbor.

In contrast to Sewall,[1] who did not find a single "foreign body giant cell" in the examination of 1,544 tonsils, we have found such giant cells to be of frequent occurrence. Either with or without accompanying epithelioid or fibroblastic proliferation, they constitute foreign body pseudotubercles, which, it has been stated by some, resemble true tubercles so closely that the diagnosis of tonsillar tuberculosis by histologic methods alone is thereby somewhat invalidated. We do not consider this objection to be well founded, for the foreign body pseudotubercles are as a rule readily differentiated by the presence of the foreign body itself or of a vacuole which represents its former location, provided it has been soluble in the reagents used in the preparation of the section. Attention to this detail and to the more irregularly syncytial character of the giant cells enveloping gross foreign bodies should prevent the error of mistaking the foreign body pseudotubercle for a true tubercle. To call attention to the fact that it is possible for the opposite error to occur is the purpose of this paper. If, through necrosis and subsequent calcification of the interior, a giant cell comes to exhibit an intracellular concretion, such a true tubercle may erroneously be considered a foreign body pseudotubercle. We have found such intracellular bodies in several cases of undoubted tonsillar tuberculosis.

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*From the Department of Pathology, University of Michigan, Ann Arbor, Mich.

A prolonged search of the literature has provided but two descriptions* of tonsillar tuberculosis showing intracellular concentric concretions of the sort here described. One of these authors considered the possibility of confusion with foreign body pseudotubercles. Gottstein[2] (1896), in describing the microscopic appearance of his case IV, writes:

"There are typical Langhans' giant cells in the tubercles. Within some of the tubercles peculiar bodies are found. These are observed only in a few sections and in but two areas near a connective tissue septum. In a large giant cell there is to be seen a concentrically laminated body, staining intensely with hematoxylin and having a clearer center in which there is a peculiar stroma or network. In some cases this body appears to extend beyond the giant cell. These bodies give the impression of being composed of lime salts, which is confirmed by examination with Nicol's prisms." After considering the possibility of laminated islands of epithelium becoming calcified and producing foreign body pseudotubercles he concludes that this case must be considered a combination of true tuberculosis with foreign body pseudotuberculosis, lacking, however, absolute proof of either, since neither tubercle bacilli nor cellular inclusions could be demonstrated. It is entirely evident from his discussion of the case that he felt that no positive diagnosis of these peculiar calcareous bodies could be made.

Uffenorde[3] (1903) was aware of this observation and refers to it in his description of the microscopic findings in his own case III. In an area of numerous epithelioid tubercles with many very large giant cells, he found one giant cell in which there was a concentrically laminated structure with peculiar border and clefts which he recognized as being like those described by Gottstein. He does not, however, discuss its significance.

In three instances, among 142 cases of microscopically verified tonsillar tuberculosis from 8,600 pairs of tonsils exam-

*Grosvenor (Journ.-Lancet, Minneap., 1913, XXXIII, 653-656), figures these concretions very characteristically and recognizes their calcareous nature in the legend, but does not refer to them in his text.

ined,[4] we have found concentrically laminated concretions of the type noted by Gottstein and Uffenorde. These may be presented briefly as follows:

Case No. 2659-U. Male, age 17. Bilateral tonsillectomy for so-called septic tonsils. Microscopic diagnosis: One tonsil shows only a chronic hyperplastic tonsillitis with hyperkeratosis and increased stroma. The other tonsil shows numerous tubercles scattered throughout about two-thirds of its substance. These are chiefly epithelioid in type, some with central caseation. Giant cells are numerous and large, and in the interior of many of these there are concentrically laminated bodies, staining deep bluish purple with hemalum and eosin, apparently calcareous in nature. Advanced unilateral tonsillar tuberculosis.

Case No. 501-V. Machinist, age 24. Double tonsillectomy for recurring tonsillitis. Microscopic diagnosis: Chronic hyperplastic tonsillitis. Large colonies of cocci. Hyperkeratosis. Bone and cartilage formation in the capsule. In each tonsil there are groups of epithelioid and giant cell tubercles localized about a single crypt. In one tonsil these are chiefly epithelioid and tend to become confluent without caseation. In the other, tubercles are much more numerous and contain giant cells, in many of which there are small blue staining (with hemalum and eosin) bodies. Some of these concretions have a more lightly staining area in the center and practically all show some degree of concentric lamination.

Case No. 1273-W. Female, age 10. Comes from an institution for dependent and defective children for bilateral tonsillectomy. No further history. Microscopic diagnosis: Both tonsils show a moderate chronic hyperplastic tonsillitis and in both there are large numbers of scattered epithelioid tubercles, many of which show an active caseation. In both tonsils there are, within undoubted tubercles, giant cells that contain laminated bodies, apparently concretions. The smallest of these bodies stain a light blue with hemalum and eosin, while the larger ones, some of which occupy nearly the entire interior of a giant cell, stain a deep purplish blue. Active bilateral miliary tonsillar tuberculosis.

The bodies thus noted as occurring within the giant cells of true tuberculosis vary in size from minute bluisn dots up to masses almost filling the largest cells. They are usually rounded in outline, although rarely perfectly spherical, and in most cases show a definite concentric striation or lamination which is much more evident upon focusing upon different levels than it can be made to appear in photographs. Their density greater than that of the surrounding cell substance, is shown by their tendency to tear out or to fragment during sectioning. The staining reactions are those of lime salts; bluish purple with hemalum, yellowish brown to brownish black by the von Kossa silver method and blue with toluidine blue. Their formation apparently results from a necrosis of the cytoplasm of the central portion of the giant cell with subsequent deposit of lime salts in or about the necrotic focus. In this way the lighter center and the concentric lamination can both be explained.

In each of the three cases noted above, other tubercles, presenting the criteria necessary for the histologic diagnosis of tuberculosis, but without the intracellular concretions, were present in the same areas with those containing them, and differing in but this one respect from them. There was no hesitancy in making a diagnosis of true tubercles, with giant cells containing concentric concretions, in each instance.

CONCLUSIONS.

1. In three out of 142 cases of tonsillar tuberculosis, diagnosed histologically, concentrically laminated concretions were found in the central cytoplasm of some of the Langhans' giant cells.

2. The presence of such concretions gives rise to the possibility of interpreting the true tubercles containing them as foreign body pseudotubercles, thus reversing the type of error usually considered in connection with pseudotubercles in general.

3. The characteristic concentrically laminated structure differentiates these concretions from the foreign bodies usually found in tonsillar pseudotubercles.

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4. Weller, C. V. The Incidence and Histopathology of Tuberculosis of the Tonsils. Arch. of Int. Med., 1921, XXVII, 631-660.

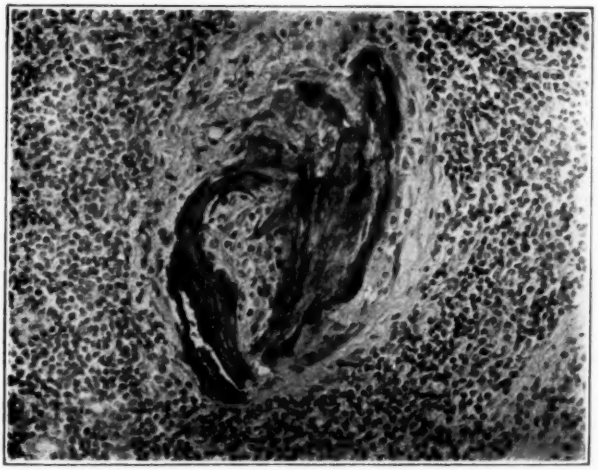

Figure 1.

Figure 1. Photomicrograph of a tonsillar foreign body pseudo-tubercle containing calcareous material arranged in irregular fibrillar laminated masses. Probably calcified kerato-hyalin acting as foreign body. Irregular syncytial giant cells about the foreign body. Hemalum and eosin stain. Zeiss "B" objective without ocular.

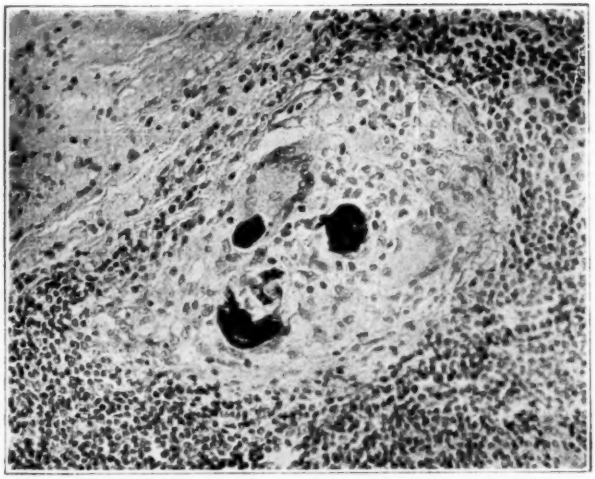

Figure 2.

Figure 2. Photomicrograph of true tubercle containing numerous giant cells and three intracellular concretions, somewhat laminated, the largest of which is, in part, torn out in the cutting. Case 501-V. Many other tubercles without concretions were found nearby in the same section. Hemalum and eosin stain. Zeiss "B" objective without ocular.

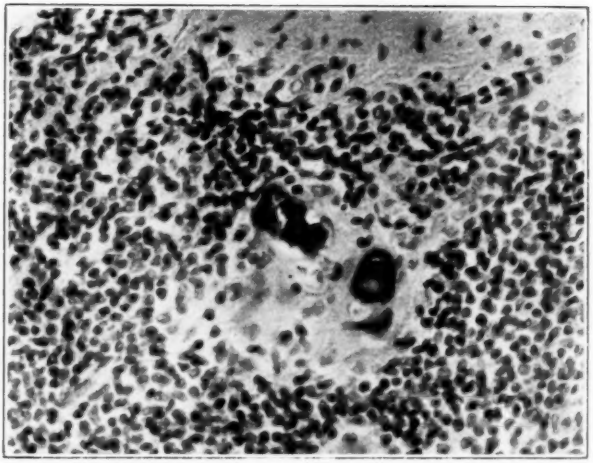

Figure 3.

Figure 3. Photomicrograph of another tubercle in Case 501-V showing concentrically and irregularly laminated concretions within and nearly replacing the giant cells. Hemalum and eosin stain. Zeiss "DD" objective without ocular.

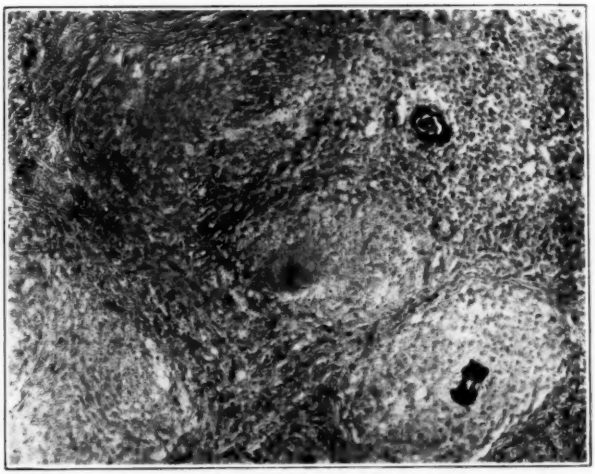

Figure 4.

Figure 4. Low power photomicrograph, Case 2659-U. Numerous tonsillar tubercles in two of which concretions occur within giant cells. One of these concretions shows very well the concentric lamination so frequently found. Hemalum and eosin stain. Zeiss "B" objective without ocular.

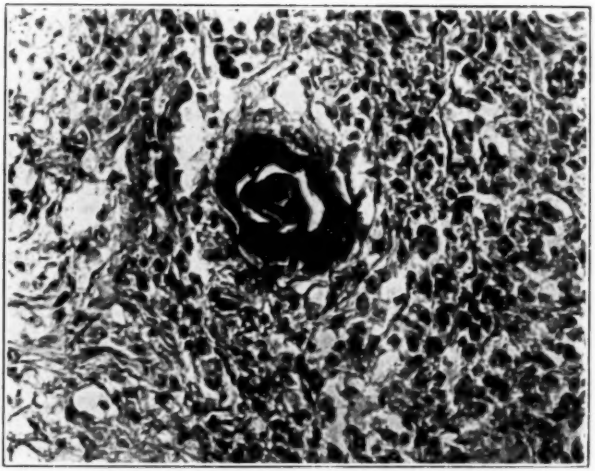

Figure 5.

Figure 5. High power photomicrograph of one of the concretions shown in previous figure. Concentric lamination and lighter staining in central portion are evident. In this, as in all other cases, lamination is much more evident while focusing up and down through the thickness of the concretion than it can be made to appear by a photograph at any one focal plane. Hemalum and eosin stain. Zeiss "B" objective with ocular.

V.

A DEMONSTRATION OF THE PHYSICS OF SUCTION APPLIED TO THE NOSE WITH MODIFICATION OF THE USUAL TECHNIC.

By Samuel Iglauer, M. D.,

Cincinnati, Ohio.

In recent years the use of suction apparatus has become very popular in the diagnosis and treatment of exudative diseases of the paranasal sinuses. The simple rubber bulb suction outfit originally used has in a large measure been supplanted by the electric vacuum pump, which is much more effective in action. Unfortunately, despite these technical improvements, but little attention has been paid to the physical principles underlying the use of negative pressure, and judging from the report of a discussion of this subject (Laryngoscope[1]), considerable confusion seems to exist regarding these principles. A disregard of the physics involved has also at times led to extravagant claims for this method of treatment, which are not warranted by the facts.

Many years ago Uffenorde[2] presented a critique of this subject and, employing a rubber suction bulb, performed some experiments on the antrum of the cadaver to explain the physics involved. Heermann[3] also explained the physics somewhat empirically and based his statements chiefly on clinical evidence.

The experiments which I have performed have been with the electric pump and are similar to but not identical with those of Uffenorde. From the standpoint of physics and for purposes of demonstration, any accessory sinus of the nose may be likened to a glass retort having a single narrow outlet. The position of this outlet varies according to the anatomic structure of the particular sinus. In the frontal sinus the outlet is at the bottom of the cavity; in the antrum and sphenoid sinuses it is very near the top; with the ethmoids the position of the outlet varies with each individual cell.

If such a retort be partially filled with water and have its

neck connected by tubing with a suction pump, and if in addition a vacuum gauge be attached, air tight, above the fluid in the retort, we can reproduce very closely the physics of artificial suction applied to the paranasal sinuses.

Experiment I. With the retort connected as described above, with the level of the contained fluid below the outlet of the retort, it is evident that upon creating a partial vacuum in the outlet of the retort there will be no movement of the fluid within the vessel, and that the vacuum gauge on the pump and on the retort will register the same.

Experiment II. If the retort be tilted so that the fluid covers the outlet and if a partial vacuum be created in the outlet, the supernatant air in the retort will be under greater pressure than that in the suction bottle, and this unbalanced pressure will force some of the fluid out of the retort. As this occurs the air in the retort may be seen to expand until the vacuum reading in the retort and pump becomes the same, when the flow will cease. Fig. 1.

In order to withdraw more fluid from the retort the partial vacuum within the latter must be overcome by removing the suction attachment, permitting air under atmospheric pressure to bubble into the retort. Suction may then be reapplied when more fluid will be withdrawn. In order to completely empty the vessel, negative pressure alternating with the admission of air must be employed a number of times, depending upon the degree of vacuum, the diameter of the outlet and the relative amount of fluid and air originally contained within the retort.

Experiment III. A Carrel tube sealed at one end and having two small lateral openings was used. Two retorts, one containing fluid and the other empty, were attached to these lateral openings. Suction was then applied to the open end of the Carrel tube, drawing fluid from the retort into the latter. Upon interrupting the suction and permitting air to rush in, it was found that some of the fluid was forced into the previously dry retort. In this experiment the Carrel tube represented the nasal cavity and the two retorts accessory cavities.

The clinical application of this experiment lies in the possibility of drawing pus out of one sinus and by very suddenly

changing from negative to atmospheric pressure forcing the pus into a neighboring and unaffected sinus.

In order to reproduce these experiments under conditions almost identical with clinical experience, the following procedure was adopted:

Experiment IV. Roentgenograms of the head of a cadaver were taken to determine the shape and size of the frontal sinus and antrum. A round trephine opening was then made into the external wall of each of these sinuses. A thick flat piece of glass accurately ground to fit each trephine opening was then inserted as nearly air tight as possible (putty or cement). This glass served as a window through which the behavior of fluids within the sinus could be observed under varying conditions. A small secondary accessory opening was drilled into each sinus. Through this opening the sinus could be filled with fluid, after which the opening could be plugged with a stopper. The posterior nares were closed air tight with rubber balloons. The suction nozzle was then applied to the anterior naris. The fluids used were either water, or preferably starch water, which more closely resembles pus in consistency.

Experiment V. Under these conditions, with the head erect and the antrum almost full, suction failed to lower the level of the fluid. If, however, the head were tilted forward and inclined to the opposite side, suction partially emptied the antrum. Upon discontinuing the suction air could be seen bubbling into the antrum to replace the partial vacuum previously induced by the suction. By repeating this process the antrum could finally be practically emptied.

Experiment VI. Frontal Sinus. The outlet of the frontal sinus was partially plugged with cotton, simulating an inflamed mucosa. When the sinus was nearly full of fluid the latter did not gravitate into the nose. With the head erect, upon applying suction part of the fluid was withdrawn. Interrupting the suction, air could be seen entering the cavity. Upon reapplying suction the sinus could be emptied. It will thus be seen that the behavior of fluids in the sinuses was practically identical with that of fluids in the retort.

It may be inferred that to empty the sphenoid it would be necessary to tilt the head forward. The positions of the ethmoid openings are too variable for any general rule. The experi-

ment of drawing fluid out of one sinus by suction and then admitting air to see if the fluid will be forced into adjacent sinus, has not been reproduced entirely to my own satisfaction and requires further trial.

The practical conclusions to be drawn from these experiments are:

First, in order to drain a sinus by negative pressure the head must be placed in the most favorable position—that is, with outlet of the sinus in the most dependent position.

Second, suction should be interrupted to permit air to force its way into the sinus.

Third, the inrush of air after suction may force part of the secretion withdrawn from a diseased cavity into an adjoining sound cavity. This may be obviated by preventing a too sudden inrush of a large volume of air.

Fourth, these experiments do not take into account the pressure due to exudation of fluid in an inflamed closed cavity.

A Modification of the Usual Therapeutic Technic.—The usual method of inducing negative pressure within the nose consists in applying the nosepiece of the suction bottle within the nostril, while the other nostril is being blocked by finger pressure, the patient meanwhile closing off the pharynx by phonating or swallowing. The objections to this method are that continuous suction cannot be maintained, while the closure of the pharynx is often incomplete, and the patient is apt to complain of the disagreeable sensation in the throat and ears during the procedure. As Wells[4] puts it, "The chief drawbacks to the use of ordinary suction are, first, the force necessary to be effective is generally attended with considerable pain, and second, we cannot exclude the eustachian tube from its action." According to the brief statement of Coffin,[5] "The nasal chamber may be closed either by instructing the patient to say Ka-Ka-Ka, or the ballooning of a small rubber bulb in the choanæ."

Most of the objections cited above may be obviated by balloon closure of the choana, and it is concerning this method that I wish to speak of more in detail.

The technic is as follows: The inferior meatus is first cocainized. The finger of a rubber glove makes an admirable balloon. It is inflated to the size of a walnut (using a Politzer

bag) and tied off with a cord, having one long and one short end.

To one end of a soft rubber catheter a piece of cord about two feet long is tied. The catheter is then passed through the nose and withdrawn through the mouth, bringing the cord after it. This is simpler than the usual method of fishing the cord out of the pharynx.

The catheter is now detached and the balloon tied to the end of the cord protruding from the mouth. The balloon is then drawn into the choana by traction on the nasal end of the string. It is held by the patient or by the weight of a hemostat.

In addition to this method, I have tried to introduce a long stemmed balloon through the nose and inflating the balloon after it reaches the pharynx. I have also used the Boetscher inflatable postnasal bag, but neither of these methods is as satisfactory as the one described above.

With a balloon in place, one can induce continuous negative pressure in the nasal chamber with but little discomfort to the patient. Sensible children will also tolerate it. My youngest patient was a boy, aged ten years, who received numerous treatments with much benefit. A girl, 16 years old, suffering from pronounced ethmoiditis, recovered after fourteen treatments, although at first it appeared to be an operative case.

The treatment may be prolonged over a considerable period, and the patient can tolerate a higher vacuum up to twenty or twenty-five inches of mercury. Suction may be alternated with air admission as desired.

In conclusion, it may be stated that this method greatly enhances the value of negative pressure in the treatment of sinus disease.

701 RACE STREET.

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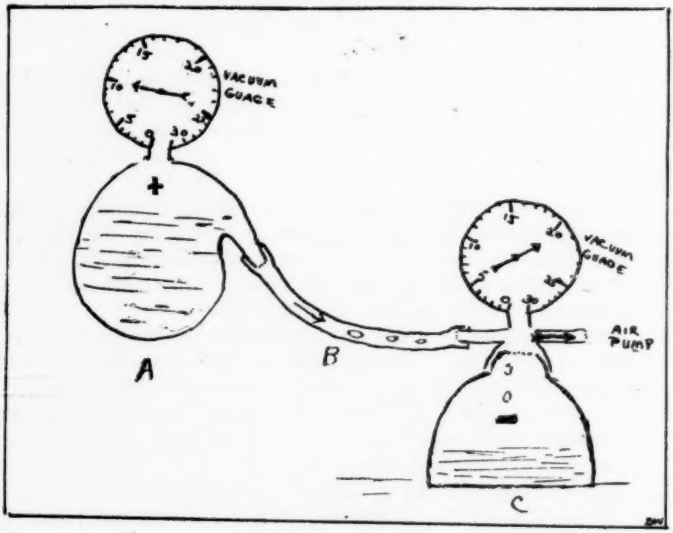

FIG. I

Fig. 1. A represents a paranasal sinus partially filled with fluid. B represents the nasal chamber. C, a suction bottle applied to the nostril. When a partial vacuum is created in C, a vacuum is also created in A, but at first a lesser vacuum than in C, as indicated by plus and minus signs. The fluid will be forced out of A by the unbalanced air pressure until the vacuum readings in A and C become the same, when the flow will cease. In order to get any more fluid out of A it will be necessary to allow air to enter A and then to apply suction as before.

VI.

A NEW LOCAL ANESTHETIC FOR NOSE AND THROAT WORK.

By Albert E. Bulson, Jr., M. D.,

Fort Wayne, Indiana.

As chairman of the committee appointed by the Section on Ophthalmology of the A. M. A. to study local anesthesia in ophthalmic work, I was asked by the Council on Pharmacy and Chemistry of the A. M. A. to submit to the members of the committee some samples of butyn, a new local anesthetic manufactured by the Abbott Laboratories, with a view of determining and reporting upon its efficiency and possible advantages in clinical ophthalmic work. The result of the work done by the committee and the conclusions formed are found in a communication published in the Journal of the A. M. A. Feb. 4, 1922. White butyn was being tested clinically in eye work it also was being tested rather thoroughly by the writer and his associates and assistants in nose and throat work, and it is the latter phase of the question which brings forth this communication.

According to the statement of the manufacturers, which practically is confirmed by the Research Committee of the Council on Pharmacy and Chemistry of the A. M. A., butyn is a synthetic anesthetic chemically known as paraaminobenzoyl gamma di-n-butylamino-propanol sulphate. It is produced in powder form, has a bitter taste, and is very soluble in water. Professor Sollman of the Research Committee of the A. M. A., says that butyn is two and one-half times more toxic than cocain when injected hypodermically into albino rats, and Professor Hatcher, of the same committee, says that the fatal dose of butyn when injected intravenously into cats is about equal to that of cocain, though sublethal doses are more dangerous than with cocain. Notwithstanding these findings concerning toxicity, Sollmann further states that the results secured by laboratory tests indicate that butyn may take the place of cocain in whole or in part for surface anesthesia of

mucous membranes, and that it may be superior for such purpose to other synthetic anesthetics since it can be used in materially lower concentrations, presumably because of lower absorption. On the other hand, he states that butyn does not appear promising for injection, since the toxicity is materially greater than that of cocain.

In view of this report concerning toxicity, as determined by animal experiments and verified by the animal experiments conducted by our committee, the use of butyn in nose and throat work was undertaken with caution, as it was recognized that the nasal mucous membrane with its greater area and increased absorbing surface, as compared to the conjunctiva, made it advisable to begin with weak solutions and use smaller amounts until the toxicity in the average human could be determined. Therefore, at first butyn in 1 per cent solution was applied once over small areas within the nose, and tests for anesthesia made subsequently at one to three minute intervals. These tests indicated a mild surface anesthesia produced within one minute. Later these tests were extended to include surface anesthesia sufficient for everything pertaining to an examination, including the use of applicators and eustachian catheters, as also for the allaying of the discomfort occasioned by the application of astringents or escharotics. Still later butyn in 2 per cent solution, by repeated application, was employed routinely in all conditions within the nose and throat where surface anesthesia is desired. Finally the strength of the solution was increased to 5 per cent with a view of securing anesthesia for all of the major intranasal operations and testing out more completely the penetrating effect of the anesthesia as also the possibilities of bringing about toxic manifestations.

In the eye butyn produces hyperemia of the ocular and palpebral conjunctiva, more marked in some individuals than others, and more marked in pathologic eyes or those previously the seat of pathologic lesions, though this hyperemia is controlled readily by epinephrin. In the nose and throat a similar hyperemia is produced, but it is less noticeable than in the eye and less objectionable. As butyn produces no ischemic effect there is no shrinking of tissues following its use, such as follows the use of cocain solutions, hence the condition of

the intranasal tissues remains approximately the same except for the anesthesia. This is a valuable feature in those cases where a portion or all of a turbinate is to be removed.

I now believe that butyn combined with epinephrin produces a more profound anesthesia than when the butyn is used alone, and the combination has the added advantage of furnishing a relatively bloodless field as well as limiting the absorption of and decreasing the chances of toxic effect of the butyn.

While solutions of butyn in varying strengths of from 1 to 5 per cent have been used, yet it has been found that a 2 per cent solution is sufficiently effective in the ordinary cases, and in view of the possible toxic effects it is considered unnecessary to use the stronger solutions if the milder will do the work. However, for several months a 5 per cent solution combined with epinephrin has been used routinely in major operations within the nose and throat, with very satisfactory anesthesia, and, up to date, without the slightest toxic effects. It is conceivable that in the throat, where absorption is less marked than in the nose, a stronger solution may, after more extended experience with the anesthetic, prove preferable.

Extended use of butyn in nose and throat work finally led to a rather fixed routine in securing satisfactory local anesthesia. For intranasal operation, a 5 per cent solution of butyn combined with epinephrin is swabbed over the operative field and well beyond if possible. Within two or three minutes following the first application, flattened pledgets of cotton, soaked with the solution, but from which the surplus has been squeezed out, are applied snugly over the operative field and whenever possible over the source of sensory nerve supply. These pledgets are removed at the end of five to eight minutes. Five minutes later operative procedures may be commenced with the assurance that in practically all cases the patient will suffer no pain or even discomfort. The exceptions are rare, and comparable to the exceptions under the most thorough efforts to secure anesthesia from cocain, where occasionally we encounter a case of either unusual sensitiveness, or antagonism to the anesthetizing effect of the anesthetic through psychic or other disturbances, and pain and discomfort in such cases occurs irrespective of the agent or technic employed in at-

tempting to anesthetize the tissues. To offset the fear and nervousness that occasionally is present the patient is given a preliminary hypodermic of morphin and atropin, or morphin and hyoscin, but this practice is a routine procedure when cocain is used.

For the ordinary throat operations, including adenectomy, but omitting tonsillectomy which has not been tried under surface anesthesia alone, the practice has been to make about four applications of a 5 per cent solution of butyn to the operative field and well beyond, due care being observed to prevent any of the solution from being swallowed by the patient. For laryngeal operations the applications are made directly into the larynx, though the faucial mucous membrane is swabbed at least once in order to do away with the irritability.

Up to the present time I have had a limited experience with butyn in infiltration anesthesia, but so far it has proven very satisfactory and without toxic effects. I have evidence from several dentists to the effect that infiltration anesthesia with butyn is not only safe but very satisfactory, and it is a well known fact that dentists use infiltration anesthesia extensively and for purposes that really test the efficiency of the anesthetic agent used. In producing infiltration anesthesia I have employed butyn in one-half and 1 per cent solutions, the former being preferable on account of lessened risk of toxic effects.

Under butyn anesthesia, obtained in the manner described, nearly all of the major throat and intranasal operations have been performed, including submucous resections, removal of tumors, turbinotomies, opening of all of the accessory sinuses intranasally, exenteration of the ethmoid cells, removal of adenoid tissue from the nasopharynx, tonsillectomies and removal of benign tumors from the larynx. While all of these operations have been performed under butyn anesthesia during the last few months, many of them, like submucous resections, may times, in no instance, as already stated, has the patient complained of severe pain, and in nearly all instances the patient has not complained of even real discomfort from the operative procedures. Thus in forty-four consecutive submucous resections of the septum, and twenty-three consecutive intranasal operations on the accessory sinuses, 5 per cent anesthesia being employed, the patient in each instance, upon being

questioned, declared that the operative procedures had been without pain.

Satisfactory anesthesia for major operations lasts from thirty to forty minutes, oftentimes longer, and in most cases a fair anesthesia will continue for over an hour. The solutions keep well when not exposed to air, and boiling does not seem to impair their anesthetic efficiency.

In no instance, including the hundreds of times that butyn has been used for minor operations and in eye work, have the slightest toxic manifestations been noted. Considering that this means that in the major operations, where a larger quantity of the drug is required and the absorbing surface is larger, no toxic symptoms have been noted, and that in the same cases had cocain been employed in the usual manner, several instances showing more or less toxic symptoms would have occurred, butyn seems to present evidences of superiority. Furthermore, the anesthesia produced by butyn is in the main deeper and more profound than with cocain, and if anything more lasting. This has been noted particularly in accessory sinus work and in the removal of adenoid tissue. Anyone who has attempted to remove adenoid tissue from the young adult under cocain anesthesia, even when a 10 per cent solution is used, knows how infrequently anything like a satisfactory anesthesia has been secured, as he also knows that the use of cocain for that purpose is accompanied by considerable risk of toxic effects.

Concerning the toxicity it is pertinent to remark that butyn has now been used thousands of times by other clinicians, with several of whom I have compared notes, and by many dentists who usually use anesthetics with less than the usual caution, and up to the present writing not a single case of toxic disturbance has been reported. This includes the cases in which butyn has been used experimentally for infiltration anesthesia. It also includes many cases in which solutions of 5 per cent and even stronger have been used rather than the 2 per cent which in all probability will be found sufficient for all ordinary operative work that will be attempted under local anesthesia.

The question arises as to the value of animal experimentation in determining the toxicity of butyn. If the drug is two

and one-half times as toxic as cocain, or, in other words, if a 2 per cent solution is equal in toxicity to a 5 per cent solution of cocain, why is it that the free use of a 2 per cent solution of butyn in thousands of cases has not produced a single report of toxic disturbance? Certainly had 5 per cent cocain been used in the same cases and in the same manner sufficient to produce operative anesthesia, quite a number of at least mild toxic cases would have been developed. As a matter of fact, as already stated, 5 per cent butyn has been used by the writer many times for major intranasal operations without noting the slightest signs of toxic disturbance. However, it is very probable that if butyn ever is used as extensively as cocain, there will be cases of toxic effects reported, and then it is a question to decide whether the symptoms are due partly to psychic causes, to idiosyncrasy or to error in using more of the drug than required to produce the desired effect.

Aside from the remote and perhaps questionably possible toxic effects from butyn anesthesia secured in the manner suggested, certain facts concerning this new anesthesia seem to have been clearly established:

1. It is more powerful than cocain, a smaller quantity being required.
2. It acts more rapidly than cocain.
3. Its action is more prolonged than that of cocain.
4. It is less toxic in the quantity required.
5. It is slightly antiseptic.
6. It is less irritating than cocain.
7. It causes no shrinking of tissues.
8. It produces no drying effect upon tissues.
9. It has no ischemic effect.
10. It can be boiled without decomposition.
11. It is nonhabit forming.
12. Its purchase requires no narcotic blank.

406 West Berry St.

VII.

A STUDY OF THE SCHWABACH TEST IN ONE HUNDRED CASES.*

By Robert Sonnenschein, M. D.,

Chicago.

The study here presented was made on 100 unselected cases in the University Nose and Throat Clinic of Professor Gerber of Koenigsberg in 1909. These were examined in detail by means of all the usual functional tests. The result of the analysis of the Weber test (read before the Chicago Laryngological and Otological Society in February, 1911) and of the Rinne test (accepted as a thesis by the American Laryngological, Rhinological and Otological Society, June, 1921) have already been published, and I will take the liberty of quoting somewhat from these papers. The writer believes that the great importance of the functional testing of the ears warrants the reporting of detailed findings.

Inquiries addressed to prominent European otologists at the time examination of the cases was in progress gave the following information regarding the forks employed and the region of the head on which they were placed. While we are perhaps accustomed to regard the Schwabach test as made by holding the fork in the midline of the vertex, many of the otologists quoted use the mastoid processes (just as in the Rinne) or the forehead instead of the vertex. In this country Randall and others employ the Gardner-Brown modification with the fork at the nasal root and the head bent backward.

Panse (Dresden) employed the a^1 fork (435 v. d.) on the mastoid process; Heiman (Warsaw) uses the weighted C (64 v. d.) and c (128 v. d.) fork, usually on the vertex; Schmiegelow (Copenhagen) uses a^1 (435 v. d.) on the vertex; Urbantschitsch (Vienna) uses C (64 v. d.), c^1 (256 v. d.) and c^2 (512 v. d.) on the mastoids; Hartmann (Berlin) ap-

*Read at meeting of American Academy of Ophthalmology and Otolaryngology in Philadelphia, October 19, 1921.

plies c (128 v. d.) on the mastoids; Alexander (Vienna) uses the weighed c^1 (154 v. d.) either on the forehead or the mastoid; Politzer (Vienna) always uses c^1 (256 v. d.) on the mastoid; Moeller (Copenhagen) stated that he used a^1 (435 v. d.) applied to each mastoid; Denker (Erlangen) and Siebenmann (Basel) applied forks A (108 v. d.) and a^1 (435 v. d.) on the vertex; Ucherman (Christiania) used the unweighted c^1 (256 v. d.) on the mastoids; Bruehl (Berlin) uses c (128 v. d.) on the vertex; Passow (Berlin) rests c^1 (256 v. d.) on the vertex; Kuemmel (Heidelberg) uses c (128 v. d.); Lucae (Berlin) employs the weighted c (128 v. d.), both placing the fork on the mastoid. Of the fifteen otologists mentioned, we see that eight usually place the fork on the mastoid, six rest the fork on the vertex and one (Alexander) chooses either vertex or mastoid. This at first seems surprising, for we were under the impression that most otologists were making the Schwabach by placing the fork in the midline of the vertex just as in the Weber test. It then occurred to us that it might be wise to note the relation between the results obtained via vertex, forehead and the mastoid.

The three forks used by us in making the Schwabach test and also the Weber and Rinne were Edelmann's A (108 v. d.); second, the weighted c^1 (154 v. d.). [N. B.—Without weights this fork has the tone of c^1 (256 v. d.), but when weighted as used, has the tone of d sharp (154 v. d.); and, lastly, the small a^1 fork (435 v. d.), (v. d. meaning double vibrations as distinguished from single vibrations. The A and the weighted c^1 forks were excited by allowing them to drop of their own weight and height from a perpendicular to a horizontal position and striking the knee. The a^1 fork was held at right angles to the body with the flat surface of the prong uppermost, and a small pleximeter, such as is used by neurologists for testing the patellar reflex, was allowed to drop of its own weight and height from a perpendicular position directly down upon the flat surface of the prong, thus giving a uniform excitation of the fork in all cases.

Schwabach found in conduction impairment due to diseases of the external and middle ear that a tuning fork applied to the bones of the head was heard longer than normal, and that in cases of auditory nerve affection the perception of the fork

was diminished. For this observation Schwabach advances no physical basis, but Steinbrugge believes that the difference in the perception time for the tuning fork sounds in air and bone conduction is probably due both to impairment within the region of sound conduction (including the labyrinthine part) and to the increased, normal, or diminished irritability of the nerve. In our own tests, in order to make them more objective, the average duration of vibration of the forks employed was determined by examining quite a number of normal cases. Then the difference between these figures and the ones obtained by testing other cases showed whether lengthened or shortened bone conduction was present.

In many textbooks the rule is laid down that this test is to be made by holding the fork on the examiner's head (when prolonged bone conduction is suspected), and when no longer heard, placing it on the patient's head and noting the difference in time. If shortened bone conduction is suspected the fork is first placed on the patient's head, and when no longer heard applied to the examiner's head and the difference in time again noted. Of course this method can only be used when the examiner has determined that his own bone conduction is normal. We, however, as aforesaid, have used the more objective method.

Even in normal individuals bone conduction varies, depending upon age (at or after middle age bone conduction is considerably diminished), although it may differ in persons of the same age; the thickness of the cranial bones, the size of the air spaces, such as the mastoid cells, as well as certain anomalies of the skull, depressions, traumatic changes, etc. According to Wanner and Gudden, adhesions between the dura and the bone as well as other traumatic or pathologic changes influence the Schwabach by giving a greatly shortened bone conduction in spite of normal hearing via air. The amount of the hair, the tension of the skin, contact with the auricles and the pressure with which the force is applied, all these may cause variations of the bone conduction. Politzer believes that the Schwabach alone is only in rare instances of great value in differentiating between middle and internal ear disease. When, however, the bone conduction is found prolonged, and the Rinné is decidedly negative, the Schwabach aids in making

the diagnosis of interference of the sound conducting apparatus; and where the Schwabach is shortened, together with a positive Rinne and impaired hearing, it greatly assists in the diagnosis of an auditory nerve affection. Politzer also states that "as a prognostic sign it is of considerable importance, because cases with lengthened bone conduction are usually more favorable as to their course and the result of treatment than where it is shortened." This dictum, however, we must modify by stating that in typical otosclerosis, where the bone conduction is greatly prolonged, the prognosis in every direction is poor.

Boenninghaus employs a c^2 fork and cautions against using forks much lower than this, as their heavy vibrations cause confusion in the minds of the patient in differentiating between tactile and auditory perceptions. He does the Schwabach by holding the fork against the mastoid in the region of the fossa mastoidea, with a firm contact (short of producing pain), and then periodically increasing and lessening the pressure, "thus producing an intermittent stimulation which does not fatigue the ear and at the same time facilitates the determination of the maximum stimulation (Reizschwelle)." If the sound is referred to or is said to be heard louder or entirely in the opposite ear, then of course the bone conduction in the examined ear cannot be determined; but indirectly an idea is obtained regarding this ear when the other is examined. If in the second ear the bone conduction is shortened it is still shorter in the first one; if it is normal in the second ear it is shortened in the first one; but if it is lengthened in the second ear, it really shows nothing definite about the first ear, which may have a shortened, normal, or even a prolonged bone conduction, although of course not so prolonged as in the second ear. In comparing the patient's bone conduction with that of the examiner, a difference of a few seconds with forks of long vibration time is of no significance. This may be due to several factors, such as unequal pressure in applying the forks as well as placing it on the identical spot on each mastoid; to a difference in the attention on the part of two individuals; or to variations in the thickness of the bone. One must avoid touching the auricle with the fork, as this causes the former to vibrate and give hearing by air conduction and thus prevent

the determination of the moment when the bone conduction ends. N. B., Boenninghaus: "When bone conduction is neither much prolonged nor decidedly shortened, contact of the fork with the auricle will again cause perception of the bone after it can no longer be heard via mastoid."

Bezold determines bone conduction at two pitches, employing the A and the a^1 fork (or others near them in the scale). After the forks are vigorously struck, they are placed on the vertex. Since the other ear cannot be excluded completely from hearing he considers it impracticable to test via mastoid process. "The Weber test will show in which ear the sound is heard the louder." With conduction apparatus interference, the sound is much more prolonged with A (108 v. d.) than with a^1 (435 v. d.); in fact, it often happens that the Schwabach test carried out with a A fork shows a lengthening of bone conduction, whereas the a^1 fork shows a shortening; in such cases disease of the internal ear is also present. Bezold also calls attention to the fact that slight differences in hearing the fork are of no significance. With the low forks usually employed in the Schwabach test, we must bear in mind the powers of observation and concentration on the part of the patient, and also the many adventitious sounds in our environment resembling those of the forks.

It is Mach's theory that the bone conduction is increased by any disturbance in the external or middle ear because the normal outward flow of sound is thereby hindered and a second reflection of sound towards the labyrinth produced. This presupposes, first, a direct or regular transmission from bone to inner ear, and secondly, that normally the conduction apparatus transmits sound vibrations as easily outward as inward. The first assumption is not proven; and, according to Helmholtz, the second theory is untenable because the lever action of the conducting chain, whose long arm consists of the radiating fibers of the drum membrane, easily transmits inward the slightest changes in air vibration, but cannot by means of the short lever arm, namely, the fibers of the ligamentum annulare, transmit them outward. Weber, Brunner, and Lucae believe that the increase of bone conduction in middle or external ear obstruction is partly due to the resonance of the imprisoned column of air. The presence of fluid on either side

of the drum membrane increases the bone conduction because the fluid is a better medium for transmission of sound from the bone to the membrana tympani than is the air. The theory of resonance produced by the air in the middle ear spaces does not, however, explain the occurrence (so very often noted) of increased bone conduction (negative Rinne), when the middle ear is filled with secretion. Bezold's theory is based on certain physiologic findings and experiments. For the proper sound transmission via air the conduction apparatus must be in a state of equilibrium, a slight disturbance of which, such as a pure tubal occlusion, is sufficient to produce a decided diminution in air conduction, and an equally definite increase in bone conduction. This equilibrium is likewise affected by large perforations through the drum membrane with a loss of some of the radiating fibers, and a resulting overaction of the tensor tympani muscles. Sclerotic processes in the tympanic property may also cause an increased tension in the conduction apparatus. Bezold holds that bone conduction is brought about by means of the sound conducting apparatus of the middle ear and differs from air conduction only in the fact that with bone conduction the sound waves strike the edge of the drum membrane and the ligamentum annulare and not the flat surface thereof. By experiment he showed that increased tension in the conducting apparatus and at the same time that of the ligamentum annulare, produced lengthened bone conduction and a diminution of air conduction. On this basis he claims to have a simple explanation for the findings of the Weber and Rinne reaction in the majority of cases of the middle ear affection. The increased tension ("anspannung") at any point in the conducting apparatus reduces the ability to transmit air borne sound waves, but heightens its power to conduct vibrations via bone to the labyrinthine fluid. Retjo lays emphasis on the rôle which the round window is supposed to play in bone conduction.

O. Beck and others have called attention to the diminution in bone conduction often noted in cases of lues with otherwise good hearing and no aural symptoms. He says that this lowered bone conduction may be found in 80 per cent of syphilitic subjects, and that it appears mostly in the secondary and only infrequently in the first stage of lues. Goeckermann, Barlow

and Stokes found the lowered bone conduction test (diminution in conduction of sound by bone as compared with otherwise normal hearing) positive in 78 per cent of known syphilitics in their series. According to these writers the tests agree with the positive or negative diagnosis of syphilis in 67 per cent and disagrees in 33 per cent. The test was also positive in 48 per cent in patients in whom syphilis was apparently excluded. They conclude that the diminished bone conduction has only "a restricted value as a diagnostic aid in lues owing to its high factor of error."

In the tables herewith appended (showing in seconds the length of time the three forks were heard on the vertex, forehead and mastoid), the same classification of cases is retained as in the paper entitled "A Study of the Rinné Test in One Hundred Cases." First, those with positive Rinne in both ears; second, those with positive Rinne in one ear and negative in the other; and lastly, those with negative Rinne in both ears. The cases here listed showed normal ears in 21; chronic otitis media in 25; acute otitis media in 14; auditory nerve degeneration in 15; otosclerosis in 1; chronic adhesive process in 2; otitis externa in 1; chronic tubal catarrh in 12; traumatic perforation in 1; retracted, cloudy or atrophic drum membranes in 12 cases. In the pathologic cases in some instances both, in others only one ear was involved.

BOTH EARS POSITIVE RINNE.

Age, History, Diagnosis, Etc.	Forks Used	Schwabach —Via—		Schwabach Via Mastoids	
		Vertex	Foreh'd	R. Ear	L. Ear
Case 9. Age 55, M. Affectio nervi acustici. Tinnitus and poor hearing.	**A**	**20**	**16**	**20**	**10**
	c_1	**14**	**11**	**18**	**16**
	a_1	**0**	**0**	**15**	**14**
Case 10. Age 42. F. Chr. adhesive process. No suppuration. Some affectio nervi acustici. Poor hearing.	**A**	**15**	**13**	**30**	**25**
	c_1	**30**	**25**	**40**	**40**
	a_1	**10**	**7**	**10**	**9**
Case 12. Age 17. F. Rhinitis atrophica. Drums normal. No ear symptoms.	**A**	**60**	**45**	**80**	**100**
	c_1	**55**	**40**	**70**	**90**
	a_1	**15**	**5**	**35**	**45**
Case 13. Age 21. F. Ot. Med. Acuta (dex) six months ago. Now healed. Tinnitus right.	**A**	**60**	**40**	**60**	**80**
	c_1	**45**	**35**	**50**	**70**
	a_1	**15**	**0**	**30**	**35**

Age, History, Diagnosis, Etc.	Forks Used	Schwabach —Via— Vertex	Foreh'd	Schwabach Via Mastoids R. Ear	L. Ear
Case 14. Age 19. F.	A	52	52	60	80
Epistaxis. No ear symp-	c_1	48	48	60	60
toms.	a_1	10	10	45	45
(Normal.)					
Case 17. Age 16. F.	A	35	25	70	90
No ear symptoms.	c_1	65	55	90	100
Normal.	a_1	34	24	33	35
Case 18. Age 20. F.					
Rhinitis atrophica. Laryn-	A	35	18	35	75
gitis chr. Some tinnitus	c_1	35	25	25	60
and impaired hearing.	a_1	15	0	30	45
Case 20. Age 15. M.	A	60	35	90	90
(Normal Ears.) No ear	c_1	40	25	60	60
symptoms. Deviatio septi.	a_1	18	0	32	35
Case 23. Age 19. M.					
Laryngitis tubec. Slight	A	25	25	65	70
feeling of fullness in ears.	c_1	23	23	55	65
Normal ears.	a_1	15	15	35	40
Case 25. Age 22. M.	A	35	40	70	70
Ears normal.	c_1	30	35	55	55
No symptoms.	a_1	15	18	38	35
Case 26. Age 24. F.	A	30	20	50	50
Nasal polyps.	c_1	45	30	65	70
No ear symptoms.	a_1	15	8	40	35
Case 27. Age 50. M.	A	30	30	45	60
Dev. septi. Some impair-	c_1	38	36	50	55
ment of hearing. (Rather	a_1	10	10	15	15
thick hair.)					
Case 28. Age 15. M.					
Atrophic drum mem-	A	20	20	40	40
branes. Tinnitus right for	c_1	25	25	55	55
two weeks. Some affectio	a_1	20	20	35	35
nervi.					
Case 29. Age 29. M.					
Some tinnitus left and	A	30	30	70	60
impaired hearing after	c_1	40	40	60	55
suppuration.	a_1	35	25	45	35
Case 30. Age 56. F.	A	50	45	70	65
Affectio nervi acustici.	c_1	50	35	80	70
Marked tubal catarrh left.	a_1	20	30	45	30
Case 31. Age 79. M.	A	35	0	0(?)	0(?)
Tinnitus and impaired	c_1	40	40	40	40
hearing. Affectio nervi.	a_1	0	0	25	25
	(Cannot explain reaction of A fork.)				

Age, History, Diagnosis, Etc.	Forks Used	Schwabach —Via— Vertex	Foreh'd	Schwabach Via Mastoids R. Ear	L. Ear
Case 33. Age 23. M.	A	45	50	70	70
Ethmoiditis. No ear symptoms. Rather thick hair.	c_1	40	40	70	80
Hears better via forehead.	a_1	25	35	55	55
Case 34. Age 32. M.	A	22	20	30	30
Tubal catarrh five years	c_1	20	18	30	45
ago. No ear symptoms now.	a_1	10	0	20	32
Slight affectio nervi.					
Case 35. Age 23. M.	A	20	30	70	90
Chronic laryngitis. Nor-	c_1	25	32	60	72
mal ears. Thick hair.	a_1	25	18	45	45
Case 36. Age 64.	A	50	45	80	80
Tinnitus.	c_1	40	40	60	70
Tubal catarrh.	a_1	20	25	40	40
Case 38. Age 21. M.	A	10	20	40	65
Tinnitus.	c_1	10	18	45	55
Some affectio nervi.	a_1	10	10	25	40
(Cannot explain Rinne and Schwabach in this case.)					
Case 41. Age 22. F.	A	45	50	90	80
Chr. ethmoiditis. No ear	c_1	45	55	70	70
symptoms. Slight retraction.	a_1	20	20	35	35
Case 42. Age 30. F.	A	55	60	110	120
No ear symptoms.	c_1	35	35	60	70
Normal drums.	a_1	22	22	45	48
Case 43. Age 21. F.					
Recently tinnitus and im-	A	30	30	70	70
paired hearing. Some atro-	c_1	32	32	60	60
phy of drum membranes.	a_1	10	10	35	35
Case 53. Age 15. F.	A	40	45	65	65
Adenoids.	c_1	55	55	60	60
No ear symptoms now.	a_1	30	30	50	50
(Weber to right side, though no apparent lesion.)					
Case 54. Age 27. M.	A	65	60	80	80
No ear symptoms.	c_1	55	55	75	75
Drums slightly cloudy.	a_1	30	30	60	60
Case 56. Age 15. M.	A	50	50	80	90
No ear symptoms.	c_1	45	40	80	80
Nasal polyps.	a_1	35	35	55	55
(Cannot explain Weber to left side.)					

Age, History, Diagnosis, Etc.	Forks Used	Schwabach —Via— Vertex	Schwabach —Via— Foreh'd	Schwabach Via Mastoids R. Ear	Schwabach Via Mastoids L. Ear
Case 57. Age 14. F.	A	40	45	90	95
Chronic rhinitis. No ear	c_1	40	45	60	70
symptoms. Thick hair.	a_1	20	25	45	55
Hears better on forehead.					
Case 59. Age 30. M.	A	45	45	85	85
No ear symptoms. Some	c_1	40	40	80	80
retraction of drums.	a_1	22	22	45	45
Case 60. Age 20. M.	A	40	30	75	75
No ear symptoms.	c_1	45	30	60	70
Normal drums.	a_1	20	20	45	45
Case 62. Age 26. F.	A	65	65	95	100
No ear symptoms. Drum	c_1	48	55	70	70
membranes normal. Thick	a_1	20	35	35	40
hair.					
Case 64. Age 28. M.	A	30	30	55	55
Affectio nervi acustici bi-	c_1	25	30	50	50
lat. Tinnitus left ear.	a_1	15	20	30	30
Rather thick hair.					
Case 69. Age 23. M.	A	55	58	80	90
No ear symptoms.	c_1	50	50	70	80
	a_1	30	30	45	55
Case 70. Age 27. M.					
Acute laryngitis. Tinni-	A	45	50	80	80
tus, left for two weeks.	c_1	40	30	50	50
Some affectio nervi acus-	a_1	20	15	40	35
tici. Rather thick hair.					
Case 72. Age 30. M.	A	55	75	90	90
No ear symptoms.	c_1	45	62	80	75
	a_1	50	50	60	60
Case 73. Age 40. F.					
Nasal polyps. Cloudy	A	35	50	90	90
drum membranes. Occa-	c_1	30	35	60	60
sional tinnitus.	a_1	20	22	40	40
Thick hair.					
Case 76. Age 16. M.					
Chr. Rhinitis and laryn-	A	50	60	90	90
gitis. Cloudy right drum	c_1	40	40	60	60
and feeling of fullness.	a_1	30	35	50	50
Case 80. Age 12. M.					
Rhinoscleroma. Some re-	A	45	55	90	80
traction of drums. Slight	c_1	35	38	65	65
affectio nervi acustici.	a_1	25	25	40	40

Age, History Diagnosis, Etc.	Forks Used	Schwabach —Via— Vertex	Foreh'd	Schwabach Via Mastoids R. Ear	L. Ear
Case 83. Age 20. F.	A	55	62	90	92
Rhin. hyper. Ears normal. Rather thick hair.	c_1	45	55	80	85
	a_1	20	30	50	50
Case 85. Age 46. F.					
Tumor laryngis. Affectio nervi acustici.	A	60	50	80	80
	c_1	40	40	50	50
Thin hair.	a_1	18	18	35	35
Case 91. Age 40. M.					
Rhinitis atrophica. Some cloudiness drum membranes. No ear symptoms.	A	45	50	80	80
	c_1	30	35	50	50
Moderately thick hair.	a_1	18	25	35	35
Some affectio nervi, left ear.					
Case 95. Age 32. F.					
Drum membranes normal. Increasing impairment of hearing. Thick hair. Affectio nervi(?).	A	40	45	50	55
	c_1	25	28	40	45
	a_1	10	10	25	30
Case 97. Age 22. F.	A	50	63	95	95
Rhinitis hyper. Ears normal. Thick hair.	c_1	35	45	65	65
	a_1	23	18	40	40
Case 99. Age 51. M.					
Drum membranes normal. Retroauricular abscess left opened 4 years ago. Pain in left ear past few weeks. Bald.	A	60	45	95	100
	c_1	50	40	70	75
	a_1	15	5	35	35
Case 100. Age 73. M.					
Both drum membranes retracted. "Thumping" in ears and poor hearing past few weeks. Thin hair. Slight affectio nervi.	A	30	40	55	60
	c_1	25	35	50	55
	a_1	0	10	25	25

POSITIVE RINNE ON ONE AND NEGATIVE ON OTHER EAR.

Age, History, Diagnosis, Etc.	Forks Used	Schwabach —Via— Vertex	Foreh'd	Schwabach Via Mastoids R. Ear	L. Ear
Case 2. Age 17. M.	A	68	55	90 Pos.	100 Neg.
Ot. med. supp. chr. sin.	c_1	58	50	70	75
Total destruction of drum.	a_1	42	35	58	60
Case 3. Age 13. F.					
Ot. med. supp. chr. sin.	A	70	65	110 Pos.	70 Neg.
Total destruction. Some vertigo.	c_1	55	50	70	60
	a_1	30	28	25(?)	30

Age, History, Diagnosis, Etc.	Forks Used	Schwabach —Via— Vertex	Schwabach —Via— Foreh'd	Schwabach Via Mastoids R. Ear	Schwabach Via Mastoids L. Ear
Case 5. Age 11. M.	A	60	60	100 Neg.	90 Pos.
Cat. Tubanus dextra.	c_1	55	50	70	80
	a_1	35	31	60	50
Case 7. Age 20. F.					
Radical mastoid. (Dex.)	A	30	22	40 Neg.	0
Cloudy drum (Sin). High	c_1	18	15	25	0
tinnitus.	a_1	10	5	20	0
Case 8. Age 51. M.					
Ot. med. Sup. Chr. Dex.	A	75	60	60 Neg.	70+
Ot. med. Sup. Acuta Sin.	c_1	55	45	55	55
Tinnitus right. Heard as	a_1	20	14	25	20
long on vertex as mastoid.					
Case 16. Age 16. F.					
Ot. med. Sup. Chr. Dex.	A	60	30	60 Neg.	70 Pos.
No tinnitus, etc. Heard as	c_1	70	35	60	65
long on vertex as mastoid.	a_1	20	12	35	40
Case 19. Age 62. M.					
Ot. med. sup. acuta sin.	A	70	45	45 Pos.	30 Neg.
Pain in ear. Heard as long	c_1	65	50	45	85
on vertex as mastoid.	a_1	15	15	30	30
Case 21. Age 32. M.					
Chr. tubal catarrh (left).	A	60	60	65 Pos.	50 Neg.
"Pressure" in ear, but no	c_1	60	60	80	60
tinnitus. Heard as long	a_1	30	30	40	25
on vertex as mastoid.					
Case 24. Age 49. F.					
Ot. med. sup. ac. sin.	A	80	45	70 Pos.	75 Neg.
Tinnitus bilateral. Heard	c_1	70	40	60	65
as long on vertex as mas-	a_1	22	10	25	30
toid.					

*N. B. Cases No. 2 and 3 show how independently ears react to Rinne test, one side as compared with other.

†N. B. In this case closure of left ear with finger caused fork to be heard in that ear when placed on vertex or mastoid.

Age, History, Diagnosis, Etc.	Forks Used	Schwabach —Via— Vertex	Schwabach —Via— Foreh'd	Schwabach Via Mastoids R. Ear	Schwabach Via Mastoids L. Ear
Case 32. Age 40. F.					
Healed Ot. med. chron-	A	20	18	15 Neg.	35 Pos.
ica bilateralis. Also affec-	c_1	30	30	30	60
tio nervi. Heard as long	a_1	8	8	15	30
on vertex as mastoid.					
Case 45. Age 15. F.					
Adenoids; atrophic	A	60	70	105+	100 Neg.
drums. Some impairment	c_1	50	55	80	80
of hearing.	a_1	25	30	60	60

Case 46. Age 50. M.					
Right complete destruction of drum; left retracted. Impaired hearing. Affectio nervi dex. Catarrh tub. sin. but heard as long on vertex as mastoid.	A	35	30	45 Neg.	35 Pos.
	c_1	35	30	30	35
	a_1	10	6	10	10
*Case 47. Age 14. F.					
Very unintelligent. Bilat. Ot. med. chr. Much destruction. Poor hearing.	A	55	60	70 Pos.	75 Neg.
	c_1	30	40	60	55
	a_1	20	25	25	25
*Cannot explain a_1 in this case.					
Case 48. Age 16. M.					
Acute mastoiditis left, 4 years ago. Past 3 weeks again pus. Right ear normal. Rather thick hair.	A	30	55	115 Pos.	120 Neg.
	c_1	70	85	105	90
	a_1	40	45	50	40
†Case 49. Age 28. M.					
Laryngitis tubc. No ear symptoms. Rather thick hair, but hears better via vertex.	A	50	30	80 Neg.	100 Pos.
	c_1	55	35	65	75
	a_1	25	18	42	50
†Cannot explain negative Rinn. in right ear.					
Case 51. Age 13. F.	A	65	60	80 Pos.	80 Neg.
Ot. med. acuta supp. bilat. Almost healed.	c_1	50	40	70	70
	a_1	40	30	50	60
Case 52. Age 49. F.					
Tinnitus and poor hearing. Retracted drum membranes.	A	60	70	120 Pos.	130 Neg.
	c_1	40	50	90	105
	a_1	20	12	30	50
Case 61. Age 8. F.					
Cholesteatoma right with impaired hearing. Left normal.	A	60	60	80 Neg.	85 Pos.
	c_1	45	40	60	70
	a_1	30	30	35	35
Case 63. Age 7. M.					
Ot. med. chr. sup. sin. Right normal. Child not very intelligent.	A	50	45	70 Pos.	80 Neg.
	c_1	60	60	90	90
	a_2	35	30	60	65
Case 65. Age 32. F.					
Otitis externa dex. with mild otitis media acuta, Pain right ear.	A	60	50	95 Neg.	90 Pos.
	c_1	65	55	100	100
	a_1	20	20	40	40
Case 67. Age 47. F.					
Ot. media sup. acuta. Dextrain and impaired hearing. Thick hair.	A	60	65	90 Neg.	90 Pos.
	c_1	50	60	80	80
	a_1	20	25	40	45

Age, History, Diagnosis, Etc.	Forks Used	Schwabach —Via— Vertex	Foreh'd	Schwabach Via Mastoids R. Ear	L. Ear
Case 71. Age 22. M.					
Traumatic perforation	A	40	40	100 Pos.	90 Neg.
left. Impaired hearing.	c_1	40	30	70	65
Some tinnitus. Thin hair.	a_1	25	20	40	40
Case 74. Age 55. F.					
Healed otitis media chr.	A	40	40	80 Pos.	80 Neg.
sin. Occasional tinnitus.	c_1	35	30	70	75
Subacute otitis med. dex.	a_1	22	12	85	60
Case 75. Age 45. M.	A	80	80	90 Pos.	100 Neg.
Otitis media acuta sin.	c_1	70	70	70	80
Pain left ear.	a_1	25	20	35	45
Case 77. Age 19. F.					
Radical mastoid right 2	A	50	35	70 Neg.	90 Pos.
years ago. Hearing very	c_1	45	35	60	70
poor. Left ear normal.	a_1	25	20	35	45
Case 78. Age 16. F.	A	70	60	90 Neg.	80 Pos.
Ot. med. subacuta supp.	c_1	50	40	80	65
dex. Left ear normal.	a_1	35	25	50	50
Case 81. Age 49. M.					
Healed Ot. med. acuta	A	30	40	90 Neg.	90+
dex. Ot. med. non-supp-	c_1	40	40	80	80
acuta sin. Still some hear	a_1	25	20	50	50
ing impairment right.					
Case 84. Age 13. M.					
Otitis med. acuta sin.	A	50	60	90 Pos.	90 Neg.
Right ear normal.	c_1	40	45	90	80
Rather thick hair.	a_1	35	40	60	60
Case 86. Age 11. M.	A	80	90	120 Neg.	125 Pos.
Acute tubal catarrh	c_1	70	60	110	120
right. Left normal.	a_1	45	55	55	55
Case 87. Age 51. F.					
Otitis med. supp. ac. dex	A	35	50	90 Pos.	75 Neg.
2½ years ago. Otitis med.	c_1	35	45	70	60
supp. subacuta sin. Mod-	a_1	25	38	52	45
erately thick hair.					
Case 88. Age 14. F.					
Large adenoids. Tinnitus	A	20	35	80 Pos.	50 Neg.
left. Left drum retracted.	c_1	18	30	68	68
Thick hair.	a_1	15	25	53	50
Case 89. Age 26. F.					
Dry perforation right,					
following ot. media supp.	A	60	70	105 Neg.	95 Pos.
in childhood. Tinnitus	c_1	50	65	75	70
right. Left drum cloudy	a_1	20	30	45	35
and retracted. Thick hair.					

Age, Diagnosis, History, Etc.	Forks Used	Schwabach —Via— Vertex	Foreh'd	Schwabach Via Mastoids R. Ear	L. Ear
Case 90. Age 46. F.					
Right drum retracted.	A	60	70	120 Pos.	110 Neg.
Total destruction left drum.	c_1	45	60	75	70
Tinnitus and poor hearing left. Moderately thick hair.	a_1	25	18	45	38
Case 92. Age 54. F.					
Unhealed radical mastoid left. Pains left side.	A	25	35	65 Pos.	55 Neg.
Right normal except cloudiness. Apparently totally deaf left side. Thin hair.	c_1	10	20	40	30
	a_1	0	0	20	10
Case 96. Age 24. F.					
Right normal. Ot. media supp. chr. sin. Rather thick hair.	A	50	60	90 Pos.	80 Neg.
	c_1	35	42	60	50
	a_1	18	25	38	35
BOTH EARS NEGATIVE RINNE.					
Case 1, Age 11. M.	A	60	50	110	120
Ot. med. chr. supp. after scarlatina.	c_1	55	45	85	100
	a_1	30	25	60	70
Case 4. Age 16. F.					
Ot. med. chr. s. bilat.	A	80	68	90	80
Fetid pus. Attic fistula left.	c_1	75	65	80	70
	a_1	35	28	58	46
Case 6. Age 34. F.					
Right drum normal. L.	A	50	40	55	80
shows catarrh. A typical	c_1	25	18	35	55
otosclerosis with nerve involvement. Tinnitus.	a_1	8	4	15	25
Case 11. Age 32. F.					
Affectio nervi acustici.	A	45	40	44	50
Right drum cloudy. Left	c_1	50	45	55	65
drum normal. Poor hearing and tinnitus.	a_1	7	4	12	15
Case 15. Age 11. M.	A	50	40	65	75
Subacute secretory catarrh. Bilateral. Tinnitus.	c_1	45	30	70	80
	a_1	28	25	60	65
Case 22. Age 45. M.					
Retracted drum membranes. Tinnitus and some	A	100	85	100	85
	c_1	60	60	75	60
impairment of hearing.	a_1	35	35	35	35
Case 37. Age 15. M.					
Right—Intermittent ot.	A	65	30	120	100
media chr. Left—unhealed	c_1	90	80	100	100
radical mastoid. Rather thick hair.	a_1	50	30	55	50

Age, History, Diagnosis, Etc.	Forks Used	Schwabach —Via— Vertex	Foreh'd	Schwabach Via Mastoids R. Ear	L. Ear
*Case 39. Age 17. M.					
Ot. media chr. in childhood. Right drum retracted. Tinnitus. Rhin. hyper & adenoids. Affectio nervi.	A	100	100	120	120
	c_1	90	90	90	90
	a_1	40	40	55	55
Case 40. Age 17. F.					
Ot. med. s. acuta bilateralis. Earache. Impaired hearing.	A	45	45	65	75
	c_1	60	60	75	75
	a_1	20	20	35	45
*Forks on left mastoid and forehead apparently heard in right ear.					
Case 44. Age 35. F.					
Ot. med. chr. bilat. in childhood. Now dry. Large perforations. Impaired hearing.	A	45	45	100	90
	c_1	65	65	100	90
	a_1	30	30	50	45
Case 50. Age 9. F.	A	40	40	40	40
Ot. media chronica bilat. Much destruction.	c_1	60	60	60	60
	a_1	45	45	50	50
Case 55. Age 18. F.					
Ot. med. supp. chr. bilat. Tinnitus and impaired hearing.	A	10	20	50	60
	c_1	25	30	55	65
	a_1	30	30	50	55
Case 58. Age 18. M.					
Ot. med. supp. chr. bilat. Attic fistula left. Poor hearing.	A	35	25	70	70
	c_1	20	20	60	60
	a_1	22	20	35	40
Case 66. Age 15. M.					
Ot. med. sup. chr. bilat. Impaired hearing. Mastoid operation left side.	A	65	60	110	100
	c_1	75	70	95	90
	a_1	40	30	60	60
Case 68. Age 14. M.					
Ot. media supp. acuta dextra. Ot. med. supp. chronica sinistra. Thick hair.	A	70	80	90	90
	c_1	40	45	80	80
	a_1	35	38	75	80
Case 79. Age 16. F.					
Adenoids; rhin. hyper. Cloudy drum membranes. Hearing much improved. Affectio nervi.	A	28	38	65	55
	c_1	25	32	62	50
	a_1	20	20	65	50
Case 82. Age 28. F.					
Otitis med. supp. chr. Bilateralis. Much destruction both sides. Thick hair.	A	50	80	90	100
	c_1	45	50	75	75
	a_1	30	40	60	60

Age, History, Diagnosis, Etc.	Forks Used	Schwabach —Via— Vertex	Foreh'd	Schwabach Via Mastoids R. Ear	L. Ear
Case 93. Age 20. F.					
Large polyps right; total	A	55	65	90	105
destruction left. Suppura-	c_1	55	65	80	90
tion and impaired hearing.	a_1	20	35	40	40
Case 94. Age 32. F.					
Drum membranes cloudy					
and right retracted. Im-	A	65	78	95	115
paired hearing with tinni-	c_1	55	65	80	95
tus in left ear. (Very thick	a_1	20	22	35	50
hair.)					
Case 98. Age 21. F.					
Radical mastoid opera-	A	30	45	55	75
tions both sides. Hearing	c_1	30	40	32	50
very poor.	a_1	15	20	25	42

An analysis of the figures obtained from these tables is as follows: On the vertex the average hearing for A (108 v. d.) was 48 seconds; for the c^1 weighted fork (154 v. d.), 34 seconds; and for the a^1 fork (435 v. d.) was 22 seconds. On the forehead the A fork was heard an average of 47 seconds, the weighted c^1 fork, 43 seconds (!), and the a^1 fork an average of 21 seconds. It is to be noted that the c^1 weighted fork was heard longer on the forehead than on the vertex, whereas the other forks were heard on the average longer on the vertex, despite the presence of hair in many of the cases. The grand average of all the forks showed for the vertex 37.1 seconds and for the forehead 37.3 seconds, or, practically speaking, no difference at all. Taking the averages of the two mastoids together, we find for the A fork an average duration of 76 seconds, for the weighted c^1 fork an average duration of 66 seconds, and for the a^1 fork a duration of 41 seconds, or a grand average of all forks via mastoid of 60.9 seconds.

The ratio between the total average of hearing of the three forks via mastoid and via forehead and vertex is as 60.9 to 37.3 seconds, or actually as 3 to 2. Now we do not postulate that this is always so, but can only state the findings in the series of cases reported. These were examined in a quiet room, much time and care taken to repeat the test several times on the same patient if necessary, often having the patient return a few days later in order to check up the first ex-

amination. So that we can state that these tabulations show the actual and accurate findings in these 100 cases. The duration of time that the forks were heard is longer than we usually assume or probably experience, but the only explanation for this is the one we have just given. The weighted c^1 fork was heard longer than the A fork in certain cases, viz.. both ears in cases 15 and 30; one ear, cases 19, 38 and 33; on the vertex and forehead cases, 37, 44, 40 and 66; one or both ears and vertex and forehead, cases 11, 50, 28, 17, 26, 10, 63, 65, 55, 34 and 32; on the vertex only case 81. Normal ears, cases 33, 17 and 26; cases of otitis media chronica, cases 32, 11, 37, 40, 44, 50, 66, 63; cases of otitis media acuta, 19, 65 and 81; cases of tubal catarrh, 30, 15 and 88; cases of affectio nervi austici, cases 30, 31, 11, 10 and 28; chronic adhesive process, case 10. The a^1 fork was heard longer than the weighted c^1 fork in case 74 subacute otitis media; one ear, case 18, some affectio nervi acustici; one ear, case 79, affectio nervi acustici.

The actual hearing of all forks via forehead and vertex was practically the same, often despite the presence of the hair. In 19 cases where the hair was quite thick (cases 33, 35, 57, 73, 83, 91, 97, 67, 84, 87, 88, 89, 90, 96, 68, 82, 93, 94, 98), the hearing via forehead was longer than that via vertex. In 16 cases where there is no special mention of heavy hair or where the hair is thin, the hearing via forehead was longer (cases 38, 41, 42, 25, 72, 76, 80, 100, 45, 47, 48, 52, 86, 92, 55 and 79). Thus in 35 per cent of the cases (19 with thick hair and 16 with thin hair) the forks were heard longer by way of the forehead, but in the other 65 per cent the forks were perceived longer by way of the vertex.

The fork placed on the vertex, or root of the nose (in the Gardner-Brown test), rests largely by its own weight, and the intensity of sound is not so much influenced by pressure used in retaining it in position; but when applied to the forehead, unless the patient's head is bent back to a rather uncomfortable degree, it is difficult to keep the fork in contact with the head without applying considerable pressure.

CONCLUSIONS.

1. On the vertex the average hearing for A (108 v. d.) was 48 seconds; for the c^1 weighted fork (154 v. d.), 34 seconds,

and for the a^1 fork (435 v. d.), was 22 seconds. On the forehead the A fork was heard an average of 47 seconds, the weighted c^1 fork 43 seconds, and the a^1 fork an average of 21 seconds. It is to be noted that the c^1 weighted fork was heard longer on the forehead than on the vertex, whereas the other forks were heard on the average longer on the vertex despite the presence of hair in many of the cases. The grand average of all the forks showed for the vertex 37.1 seconds and for the forehead 37.3 seconds or, practically speaking, no difference at all. Taking the averages of the two mastoids together, we find for the A fork an average duration of 76 seconds, for the weighted c^1 fork an average duration of 66 seconds and for the a^1 fork a duration of 41 seconds, or a grand average of all forks via mastoid of 60.9 seconds.

2. The duration of bone conduction in this series of tests is apparently longer than we have in routine examinations, but this finding may be due to the peculiarly favorable circumstances under which our cases were tested. Slight variations in bone conduction, as noted in doing the Schwabach test, are of no significance, since many factors, such as age, conformation of the skull bones, concentration on the part of the individual, etc., may influence the findings.

3. In this series of cases the ratio between the hearing via mastoids and that obtained by way of the vertex of the forehead was 3 to 2. Despite hair there was in most of the cases (65 per cent) practically no difference in duration of hearing via vertex or forehead.

4. Many noted authorities test bone conduction by way of the mastoid, and it would seem, in view of the results obtained in this series, that the bone conduction factor of the Rinne test could serve as a Schwabach, this eliminating testing by way of the vertex or the forehead except where the Weber test is deemed advisable, and the Schwabach is then done at the same time by the same maneuver.

The A fork (108 v. d.) is a large instrument and cannot easily be applied to the mastoid process, but the weighted c^1 (154 v. d.) is comfortably held either on the vertex, forehead, root of nose or mastoid and could thus be used for the Weber, Schwabach and Rinne tests. There is really a difference of only 46 vibrations between the A fork (108 v. d.) and the

weighed c^1 (154 v. d.) which, when weighted, gives a tone of d sharp, but there is a great difference in the weight and size of the fork.

5. The suggestion regarding the possible elimination of the A fork and use of the wighted c^1 fork may be of some value to those men who do not wish to, or are unable to obtain many forks for routine work. The writer himself is very fond of the A fork for use in the Weber and Schwabach tests where the latter is done by way of the vertex, but he simply mentions this fact for the reason above stated. The a^1 fork (435 v. d.) is most valuable, not only in doing the Rinne, but also in testing hearing of the voice by air conduction. Since its tone lies in the socalled "speech area" (designated by Bezold as extending from c^1 to g^2), it is assumed that if not thus heard there is no hearing for the ordinary range of speech. (N. B. —It is known that some of the harmonics of the sounds employed in speech may be much higher than those mentioned—e. g., the fifth harmonic of the vowel e has about 3,000 vibrations).

6. The question of the part played by the round window in bone conduction is a very important one and will require careful study.

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VIII.

TONSILLECTOMIES IN ADULTS FOR RHEUMATISM WITH CRITICAL REVIEW OF RESULTS.*

By Hill Hastings, M. D.,

Los Angeles.

Much that has been written of the tonsil operation deals with the surgical technic. Comparatively little has appeared in laryngologic literature dealing with clinical problems or the results from the patient's standpoint.

The clinical problems are, of course, not strictly within the province of the laryngologist, but the operator cannot and should not, it seems to me, lay aside his share of responsibility for the results. The overzealousness of a large part of the medical profession and the general public, too, in urging tonsillectomies, is tending at this time to bring disrepute on the operation. The duty of safeguarding it lies to a large extent with the laryngologist. The past history of operations in other surgical fields certainly impresses one with the need of greater care in selection of cases for tonsillectomy, lest the operation be greatly abused. These considerations prompted the writer to review his own (adult) tonsillectomies. A review of this kind is admittedly imperfect and far from satisfactory, but it may prove of value as a small contribution to the larger and better mass of evidence that is gradually accumulating on the tonsil question.

LIMITATIONS.

First—All adult cases in which tonsillectomies were done solely for ear, nose and throat diseased conditions are excluded, such as cases of quinsy, accessory sinus disease, middle ear disease, recurrent laryngitis and bronchitis, etc. Cardiovascular cases are excluded.

Second—Cases that date back over six years are excluded, for two reasons. First, it has been only the past six years

*Read at the meeting of the American Laryngological Association, May, 1921, at Atlantic City.

that the writer has been impressed with the necessity of using greater care in the selection of these operative cases, by doing group study, with the combination of careful examinations by competent internists, orthopedists and dentists. Second, cases that date back over a long period of time are excluded because so many other factors may enter into the question of improvement or deterioration in the health of these adult invalids.

Third—All cases are excluded that are of shorter duration of observation than four months, for it is a common experience to see marked temporary improvement follow a tonsillectomy, say for a few weeks, with recurrence of the symptoms. This seems especially true of rheumatic cases. Such cases are often lost sight of after the tonsil wounds are healed, and the subsequent results are apt to be unknown. It has been suggested that the enforced rest of the intestinal tract after a tonsillectomy has much to do with this temporary improvement. It has also been suggested that the effect of general anesthetic on the muscle spasm, more or less constant in some rheumatic cases, is decidedly beneficial for a short period of time.

These limitations left 130 cases out of 477 adult tonsillectomies. In the 130 cases, patients suffered from and sought operation because of rheumatism; most of them with impairment of general health; some, however, with no impairment of health. It seemed best to the writer to limit this report to this group of rheumatic cases, because the indications for operation were evident on account of the pain and stiffness common to all cases of this group. One could depend more upon the accuracy of the subsequent results as determined by examination of the patients, and checked up by questionnaires which were answered by all except 29 of the patients. No operation was done in any case of definite rheumatoid arthritis. No tonsillectomy was done during an acute attack of rheumatism with fever. The selection was made from patients who were not entirely bedridden, most of them confined to bed during an acute exacerbation. Many suffered pain and stiffness only periodically. Some were more severe, requiring the use of crutches or rest in bed or some immobilizing apparatus; a few had joint operations.

TABLE I.

Age	Cases
19 to 30	20
30 to 40	50
40 to 50	38
50 to 60	18
60 to 65	4
Total	130

Eighty-eight of these cases were between the ages of 30 and 50.

TABLE II.

Duration of rheumatism	Cases
1 to 6 months	26
6 months to 2 years	38
Over 2 years	48
Indefinite time or not stated	18
Total	130

TABLE III.

Parts Affected	Cases
Shoulder	51
Arms	24
Hands	43
Elbow	5
Neck	9
Back	11
Hip	11
Leg	14
Knees	37
Feet	17
Ankle	14

It is noteworthy that the shoulder joint was affected more frequently than any other joint. Owing to the anatomic construction of the shoulder joint, it is probable that it is more subject to injury from strains than other joints. It is believed that injury to a joint is frequently a forerunner of the localization of infection in that joint. The orthopedic and X-ray examinations frequently were negative, so far as making out

definite bony or cartilaginous changes, in many patients, even though they were chronic sufferers from pain and stiffness.

TABLE IV.

Character of rheumatism with results of tonsillectomy:

	Cases	Imp.	Much imp.	Cured	Not Imp.	Unk'wn Results
Chronic Arthritis—						
Mild	69	13	7	22	12	15
Moderate	28	6	4	11	5	2
Severe	4	0	0	0	4	0
Acute arthritis	3	0	1	2	0	0
Neuritis	6	1	0	0	2	3
Myalgia	20	3	2	5	1	9
Total	130	23	14	40	24	29

Of the severe and moderately severe cases, many showed bony or cartilaginous changes. In these cases where secondary foci were chronically established, results were not only more slowly obtained, if obtained at all, but complete cure was rare. It was the opinion from group study of the mild and moderately severe arthritic cases that the joint condition was a chronic infection of the synovial membrane or of the capsule of the joint. The X-ray examination was negative in cases, even though effusion existed.

TABLE V.

Throat History	Cases
Attacks of tonsillitis	54
Quinsy	9
Soreness	23
No tonsil complaint	46

In the forty-six cases where there was no history of tonsillitis or even soreness it is, of course, more than probable that in early life there had been definite attacks of tonsillitis. It is likely that a chronic infection dates back to a definite acute attack, the tonsils being streptococci carriers from that time on. How early in life a chronic infection begins is a problem in itself. The writer some time ago in examining histologically some apparently normal tonsils in very young children, searching for signs of tuberculosis, was surprised to find streaks of chronic inflammation with well defined fibrosis here and there

in many sections of the tonsil tissue. Some of these children had no history indicative of a chronic tonsil infection, but were operated on solely because of hypertrophied tonsil and adenoid.

TABLE VI.

	Cases
Abscessed teeth removed before tonsillectomy	26
Colectomy	1
Previous incomplete tonsil operations	12

TABLE VII.

Subsequent history:

	Cases
Rheumatism, improved	25
Rheumatism, much improved	15
Rheumatism, cured	40
Rheumatism, not improved	24
Unknown results	26
Total	130

The subsequent results are based on personal examination of the patients by the writer, by the internists or by the orthopedist, and checked up by questionnaires received from all of the 130 cases except 26 who could not be located. Thirty-nine and five-tenths per cent were improved or much improved; 39.5 per cent were cured; 21 per cent were not improved. Some of them gradually growing worse, some of them remaining stationary. In this whole series of tonsillectomies there were no hopelessly chronic cases operated, and it would seem that the percentage of "not improved"—i. e., 21 per cent, should not have been so high; nevertheless, one feels that many of the cases that were marked "improved" would have become hopelessly chronic cases but for the tonsil surgery. A review of the cases of rheumatism marked "cured" is worth while. Of the 40 cases in which apparent cure resulted, 22 were diagnosed "chronic arthritis mild," 11 were diagnosed "chronic arthritis moderately severe," two were acute arthritis cases and five were diagnosed "myalgia." A general survey of these cases showed that most of these patients had suffered off and on for years, but not continuously, with pain and stiffness in one or several joints, at times acute and tempor-

arily crippling. A few were crippled for months before operation. Orthopedic measures of various kinds had been tried. A few gave a history of symptoms of tonsil trouble; some no history of throat trouble. In seven cases the history showed an acute tonsillitis as the forerunner of the rheumatism. In other cases an accumulation in a tonsil crypt caused rheumatic symptoms. One such case bears reporting in detail.

Mr. H. A. S., male, age 32, seen first in 1909 on account of sore throat and cold in head. Tonsils were partly removed when a child. Attacks of sore throat without fever or disabling symptoms, three or four times a year. Antrum suppuration followed recent cold. Examination showed large red mass of tonsil tissue left side, small mass on right side. Advised tonsillectomy. Patient returned in 1910, 1911, 1913, 1914, 1915 on account of sore throat. At such times a large crypt in left tonsil was always found full of foul smelling material and tonsil tissue acutely inflamed. No quinsy, no fever. In April, 1915, patient remarked that aching during these attacks had become more pronounced and that his wrists would become so tender for a day or two that he could not grasp another's hand, and that after cleaning out the crypts, use of silver, gargle, etc., the wrist tenderness would rapidly disappear. His words were, "I'll be all right tomorrow." Six months later he submitted to a tonsillectomy. Five years later he reported he had never had a return of the rheumatism; had been absolutely relieved. This case is reported, not because of its rarity, but because it serves to bring up some points regarding the relations of a chronic tonsillar crypt infection to rheumatism.

It is the writer's observation that many adult patients who are cured or improved by tonsillectomy are of this type. It happened in this particular case that there was a direct connection noticed between the tonsil crypt inflammation and the rheumatism. In most cases no such connection is in evidence; yet the rapid and complete cure by tonsillectomy in such cases would lead one to believe that there is in some parts of the tonsil a similar diseased condition. A culture in this particular case showed streptococcus viridans and staphylococci. The question arises, what is the pathologic explanation of these rheumatic signs and symptoms that are so evanescent, lasting

a day or two, only to recur, and finally to disappear altogether after removal of the tonsils? Surely there can be no secondary foci of bacteria in the joints, as in the persistent chronic infectious arthritic cases.

In a discussion on this question, the writer's attention was called to an explanation (by an internist who has not, I understand, published his viewpoint), that seems to the writer to be reasonable. This explanation is that at some time bacteria from the diseased tonsil tissue did reach the joint in question and caused a reaction in the tissues of the joint, likely the capsule, with the development of a sensitization of the joint. The bacteria in the joint lost their virulence and finally disintegrated. Subsequently during an acute exacerbation of the old chronic tonsil focus there occurs an absorption of toxin, without bacteria entering the blood stream, which produces an anaphylactic reaction in the joint that formerly was injured by bacterial localization. Pain and possibly temporary swelling of the joint or the capsule occurs and an acute rheumatic condition is in evidence, without fever and without permanency. It is common experience to see such rheumatic symptoms rapidly disappear. Whether these frequently recurring rheumatic signs and symptoms are caused by anaphylactic reactions or, on the contrary, by direct and frequent reinfection of the joint by bacteria is, of course, not susceptible of proof.

TABLE VIII.

Operations After Tonsillectomy	Cases
Abscessed teeth removed with improvement	8
Without improvement	13
With improvement—	
Colectomy	2
Appendectomy	2
Cholecystectomy	1
Nephrectomy	1
Tonsil stump	1
General Health (Questionnaire Answers)	
Improved	48
Much improved	30
Not changed	23
Unknown	29

In one case there was no improvement following tonsillectomy. On the contrary, some six or eight months afterwards patient developed an acute polyarthritis, endocarditis and nephritis. Our examination of the nose and throat failed to show any tonsil tissue or nasal sinusitis. The teeth had repeatedly been X-rayed with negative results. One tooth, however, was a dead one, and it was removed in the hope of helping the condition. There was considerable disease around the root of the tooth; culture showed streptococcus hemolyticus. This and a few other cases have shown to us the futility of relying absoluetly upon an X-ray examination of the teeth.

One of the two colectomy cases bears brief reporting.

E. M. C., age 35, referred January, 1916, because of frequent sore throats and rheumatism of five years' duration, dating back to attack of tonsillitis. Left ankle first affected, then both ankles, knees, wrists and fingers; swelling and severe pain at times. Constantly crippled during the past year. Has had treatment of various kinds, feels that diet has alone been of value. In February, 1915, fasted absolutely for seventeen days. After seven or eight days rheumatism rapidly decreased, almost disappeared, to return on beginning to eat. Rheumatism grew so severe that in June, 1915, fasted for 26 days, took nothing but water; weight dropped from 170 to 123 pounds, with almost complete relief from pain. Never any tooth trouble. Examination shows a large, strong, apparently healthy man, except for the polyarthritis; cannot raise his arm above level of shoulder nor close hands without pain; limps badly; can walk upstairs one step at a time, but painful. Heart and lungs normal; intestinal tract apparently normal; normal b. m. daily, no indigestion. Wassermann negative. Complement fixation test for streptococcus viridans negative. Complement fixation test for gonorrhea negative. Teeth sound, especially good; not a filling in any tooth. Tonsils show signs of marked chronic infection. Upper crypts contain cheesy masses; tonsils large, red and pulpy. This case is reported in some detail to show the history of effect of diet, the excellent general health, the perfect teeth, the definite initial tonsillitis history and the marked diseased appearance of the tonsils. In this case surely a tonsillectomy was indicated and good results expected. Except for a temporary im-

provement (due likely to decrease in diet during convalescence) the tonsillectomy was of no value. The rheumatism increased. A further study showed a colon dilatation and a nine-hr. stasis. A colectomy was finally done August, 1916, with marked and gradual improvement. Four and a half years later he reported much improved, working his ranch daily, some stiffness, no recurrence of severe pains; "85 per cent cured" (patient's estimate). It seems that the colectomy rather than the tonsillectomy was responsible for the improvement in this patient.

The figures shown in the general health table were obtained from questionnaires from the patients. It is rather noteworthy that 78 of the 111 patients reported their general health improved or much improved. Two cases died. Both were chronic cases in which organic heart disease had existed for years. They were operated on largely because of the heart condition rather than because of the rheumatism, which though existing was not severe. Both cases were operated on under local anesthetic, did well so far as the operation was concerned, but died two years after the operation without having received any value for the tonsillectomy. It was the opinion that the tonsillectomy had no ill effect on the heart.

CONCLUSIONS.

The difficulties of the problem of selection of operative cases are, of course, common to us all. It has been the writer's experience to find that adult patients suffering from so-called focal infection symptoms are referred to the laryngologist for his decision as to whether or not the tonsil is the seat of a chronic infection. Other patients come with the statement that their tonsils have been pronounced infected or that a culture that has been made from the crypts showed chronic infection. The writer has taken some pains to inform all such patients that every adult tonsil is a chronic infected tonsil, from which a positive culture can be made. The same is probably true of most tonsils in children. Therefore, the necessity for a tonsillectomy depends, not solely upon the examination by a laryngologist but upon a complete study of the patient to determine all possible factors responsible for the

invalidism—rheumatism, heart trouble, etc. Charlatanism in the pseudospecialist has thrived to a large extent by virtue of the rather firmly rooted impression of the need of the removal of all infected tonsils. It seems to the writer that laryngologists should combat this idea, which is common, at least in my community, to a rather large part of the general medical profession and general public. Overenthusiasm on the part of many conscientious men has also been responsible for much unnecessary surgery. Sharp lines of selection of operative cases cannot, of course, be drawn, but there is urgent need at this time for careful group study of all tonsil patients, and a decision for or against tonsillectomy in any given case is ill advised until this has been done.

IX.

HYOSCIN AND MORPHIN AS A PRELIMINARY TO LOCAL ANESTHETICS.*

By Lee M. Hurd, M. D.,

New York.

In 1914, after using this method for nearly two years, I made a report.† Now, in the eighth year, stimulated by the findings of your committee on local anesthetics, reported before this section last year, I am prompted to take up this subject for a second time. Anything that adds to the comfort of the patient, lessens shock and reduces risk of local anesthetic intoxication is surely worth while.

In regard to the report of your committee on local anesthesia: the answers received to the question, "What toxic effects have come under your notice?" thirty-seven in number detail the symptoms of syncope or phrenic irritation. I consider that all were shock except two or three. The fatalities, excluding the mistakes in dosage, and those cases in which the anesthetic was injected into a vein, appear to me more like mental shock death, and not like fatality from local anesthesia.

The experiments on lower animals, except for toxic dosage, are of no help, because animals experience no apprehension or fear. In the human being, especially in the nervous type, which are in the great majority, apprehension and fear play a very important rôle in shock, even more important than the shock of operative trauma. Not only should the operative field be anesthetized, but the contact ceptors and the special sense ceptors should be blocked.

I wish to state again that the preliminary administration of scopolamin (hyoscin) hydrobromate and morphin sulphate has eliminated the unpleasant effects of local anesthesia, which I experienced in the past, and given me a confidence that, no

*Read before the Section on Laryngology, Otology and Rhinology of the American Medical Association at the seventy-second annual session, held at Boston, Mass., June 6-10, 1921.

†Hurd, L. M.: Laryngoscope, November, 1914.

matter how nervous or apprehensive patients may be, there will be no trouble with them at time of operation.

The operations of otolaryngology usually done under local anesthesia are expanded by scopolamin and morphin to the major group, such as mastoidectomies, laryngectomies and resections of the jaw, when general anesthesia is not desired.

DISADVANTAGE.

Though nearly all patients are ready forty-five minutes after receiving scopolamin and morphin, some require a longer time to settle down, and some require two or three doses. This makes it impossible to appoint a definite time for the operation, as is required in reserving the operating room in a busy hospital. I have had a delay of over two hours in some incidences.

The routine dose is morphin ¼ grain, scopolamin 1/100 grain. This is usually given after a light meal; if necessary, after forty-five minutes, I administer a second dose, usually half of the first dose, though this depends on whether the patient reacts to one drug more than to the other. If so, less of this is used in the second dose, and more of the less active drug.

In 300 consecutive cases a second dose was given in forty-two cases; a third dose in five cases, and a fourth dose in two cases. The third and fourth doses were usually given for long major operations. One of my first cases, a woman, became suddenly very hysterical when I was half way through the operation and was noisy, crying, but mainly laughing and noisy for several hours. In her case I had been forewarned of her hysteria; in the hospital, next day, she did not remember the hysterical outburst or any part of the operation. Four other women showed some hysteria when the first tonsil was removed, but gave no cause for complaint when the second came out. I had misjudged my patients and had not given them enough scopolamin and morphin. They probably would have been all right after the second dose.

Two of my early cases (which were mentioned in my previous report), while I was using the sitting position, had marked drop of blood pressure to 90 mg. systolic; otherwise

their condition was good and the operation was finished. In the first case, I gave a hypodermic injection of 10 minims of epinephrin and placed him in a recumbent position. In the second case, after operation, the recumbent position promptly raised the blood pressure. For the last three years all cases have been kept recumbent during the operation, and, even if the dose is not sufficient, syncope and lowered blood pressure do not occur.

Previous to three years ago, the scopolamin I was using did not act as consistently as that which I am using now. There were more cases of delirium, coma, prolonged effect, etc. The scopolamin must be pure; especially, it must not contain apoatropin as an impurity. For the last three years the action of the scopolamin which I have used has been quite as consistent as the action of the morphin. The tablets must be kept dry and fresh solution made at the time of the operation, as scopolamin in solution will break down into impure and poisonous byproducts in from twenty-four to forty-eight hours.

The patients were nearly all good risks, though the poor surgical risks did as well. When patients are ready for operation, their pulse rate is reduced, they are sleepy or sleeping and do not want to be disturbed, speech is slow and somewhat thick, there is slowed cerebration, they may be somewhat confused, and in moving from bed to operating table they have a staggering gait. Pupils may be contracted (morphin) or dilated (scopolamin). The ideal is midway. The face usually itches, the color is good.

The pulse is taken at the time the patient enters the office for operation, when the operation begins, and immediately it is finished. The average pulse in fifty cases was 99 at the time of entering the office, 85 at the beginning of the operation, and 85 at the end of the operation. This does not, however, show the whole picture; for example, 128, 88, 84 in a highly nervous patient, and 76, 76, 72 in a phlegmatic one might be taken as extremes.

The blood pressure, which was taken in a few cases a day or two before, at the beginning of the operation and at the end, shows the variations indicated in Table 1.

TABLE 1. BLOOD PRESSURE.

Before Operation		Beginning of Oper'n		End of Operation	
Systolic	Diastolic	Systolic	Diastolic	Systolic	Diastolic
122	76	110	70	124	74
170	100	180	100	200	110
150	100	150	104	162	94
132	84	120	80	150	100

The age groups in 300 cases are given in Table 2. Scopolamin and morphin combined work well at all these ages.

TABLE 2. AGE GROUPS IN THREE HUNDRED CASES.

Age	No. of Cases	Percentage
From 11 to 20	50	16+
From 20 to 30	75	25
From 30 to 40	93	31
From 40 to 50	50	16+
From 50 to 60	18	6
From 60 to 70	14	5

Having had the usual run of syncopes and varying degrees of psychic shock before I began the use of scopolamin and morphin, I now have none with its use. The patient has a steady pulse, which tends to pass the anesthetic that is being absorbed on to the liver for elimination, preventing intoxication.

Morphin can be used in larger doses if cocain is used in conjunction, and the reverse is true. Scopolamin has the same physiologic action as atropin, plus blocking of the mind. Blocking the sensory nerves with morphin and scopolamin prevents shock, and though more local anesthesia can be used, as a matter of practice less anesthetic is necessary.

The local anesthetics used were: Cocain (topically), twenty-nine times; procain (hypodermically), forty-one times; alypin (topically), 223 times, and on two occasions no anesthetic was used.

Alypin and procain are quickly eliminated and are, therefore, better than cocain. Alypin, which is as anesthetic as cocain and much less toxic, I prefer, though it is unobtainable at present. Patients are kept in the office two or three hours

after operation, during which time they are asleep. They are awakened then, and are usually in condition to be taken home. Since the previous report I have extended its use for all cases under local anesthesia, except the very minor and short operations, regardless of age or surgical risk. Whether the patient appears nervous or phlegmatic, I feel confident that if this method is used you will not have the symptoms attributed to anesthetic intoxication and the fatalities with the proper use of the local anesthetic will be greatly reduced.

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X.

NASOCILIARY NEURALGIA.

By Greenfield Sluder, M. D.,

St. Louis.

Pain in the eyes, brow and root of the nose is frequent and may be of different origins. Localization of the pain of the several origins by the patient is not precise. Pains of frontal, ethmoidal or sphenoidal sinuses, or nasal (sphenopalatine-Meckel's) ganglion, or supraorbital or nasociliary nerve origin may overlap in their sensations. This last pain is usually referred to the small district bounded by the supraciliary ridge above the supraorbital notch laterally and the nasal bones below. Sometimes it extends to the tip of the nose. Rarely it is referred to the eyes. Patients often complain that they cannot wear their glasses because of soreness of the nasal bones. Severe degrees, however, of whatever origin, may be referred beyond these limits. Pain of supraorbital neuralgia is more widespread. Pain of suppuration of the frontal or ethmoidal sinuses, under pressure, is of long-known recognition. Pain of vacuum frontal sinus origin was described in 1900. Pain of nasal ganglion origin referred to this district was described in 1908. It is usually accompanied by other painful sensations. Pain of supraorbital systemic toxic neuralgia is of classical description.

Anatomic description, copied from Quain, eleventh edition, part II, iii, 16:

"Nasociliary or nasal nerve. This nerve enters the orbit between the heads of the external rectus muscle and between the two divisions of the third nerve. It then inclines inwards over the optic nerve, passing beneath the superior rectus and superior oblique muscles, to the inner side of the orbit, and leaves that cavity by the anterior internal orbital canal. In this part of its course it furnishes a slender branch to the ciliary ganglion, one or two filaments (long ciliary) directly to the eyeball, and a considerable infratrochlear branch, which

arises just before the nerve, enters its canal on the inner side of the orbit.

Arrived in the cranial cavity, the nerve is directed forwards in a groove at the outer edge of the cribriform plate of the ethmoid bone to a small canal between the forepart of the plate and the frontal bone, through which it descends to the nasal fossa. Here it gives off internal, or septal, and external branches to the mucous membrane of the forepart of the nasal fossa, and is then continued downwards in the groove on the back of the nasal bone, to terminate as the anterior or superficial branch in the integument of the lower part of the dorsum of the nose.

The branch to the ciliary ganglion, very slender and from a quarter to half an inch in length, arises generally between the heads of the external rectus. It lies on the outer side of the optic nerve and enters the upper and back part of the ganglion, constituting its long root.

The long ciliary nerves are situated on the inner side of the optic nerve; they join one or more of the short ciliary branches from the ciliary ganglion, and, after perforating the sclerotic coat of the eye, are distributed in the same manner as those nerves.

The infratrochlear nerve runs forwards along the inner side of the orbit, below the superior oblique muscle, and parallel to the supratrochlear nerve, from which it receives, near the pulley of the oblique muscle, a filament of connection. The nerve is then continued below the pulley to the inner angle of the eye, and ends in filaments which supply the conjunctiva, the caruncle and the lacrimal sac as well as the integument of the upper eyelid and root of the nose.

The internal or septal branch supplies the pituitary membrane over the forepart of the septum, extending downwards nearly as far as the opening of the nostril.

The external branch, often represented by two or three filaments, is distributed to the mucous membrane of the forepart of the outer wall of the nasal fossa, including the anterior ends of middle and lower turbinate bones.

The anterior or superficial branch issues between the nasal bone and the upper lateral nose and runs downwards under

cover of the compressor naris muscle to the tip of the nose, supplying the skin of the lower part of the organ.

Varieties.—The nasociliary nerve occasionally (frequently, Krause) gives filaments to the superior and internal recti muscles. A branch to the lavator palpebræ superioris has also been met with (Fasebeck). In one case filaments of communication passed from a small ganglion connected with nasociliary nerve to the third and sixth nerves (Svitzer). In two instances Testut observed absence of the infratrochlear branch, its place being supplied by the supratrochlear nerve. Offsets from the nasociliary nerve, as it traverses the anterior internal orbital canal to the frontal sinus and ethmoid cells, are described by Meckel and Langenbeck; and a sphenoethmoidal (Luschka) or posterior ethmoidal (Krause) branch is said to pass through the posterior internal orbital canal to the mucous membrane of the sphenoid sinus and posterior ethmoid cells."

It is to be seen that the nasociliary nerve as it enters the nose in its uppermost anterior limit is quite near the surface of the membrane. It is more superficial than the nasal ganglion (usually). The ganglion may, however, be quite superficial (submucous), according to Krause. So it is easily understandable that an inflammation of the membrane in this part may irritate or inflame the nerve and produce pain. In older cases, with general hyperplasia of membrane and bone, it is also easily understandable that the ethmoid slit may be encroached upon to narrow its caliber and place the nerve in a more easily vulnerable position.

Differential Diagnosis.—The nasociliary nerve is more easily cocainized than the nasal ganglion. A small applicator with 20 per cent solution suffices. It is passed upward on the inside of the nose, being held forward in contact with the anterior limit of the nasal fossa until it reaches the roof of the fossa. By this procedure it arrives automatically in the apex of the angle formed by the cribriform plate above and the anterior limit of the nasal fossa. It is at this point that the nasociliary nerve enters the nasal fossa.

When the pain in this region is of nasociliary origin, such an application of cocain will stop it in a few minutes. Should it be of the other origins mentioned above, it will not be in-

fluenced by such an application. The differential diagnosis will, furthermore, reveal a tender spot in the floor of the frontal sinus if it be a case of vacuum or purulent frontal sinus origin (Ewing's sign). If it be a suppurating frontal or ethmoid sinus, pus will usually be seen in the middle meatus anteriorly. X-rays will show the frontal separated from the ethmoid. Should the frontal be totally closed, no pus will be thus seen; but the sinus will burst into the orbit. X-rays also show it. Should the pain be a supraorbital neuralgia, this nerve in the supraorbital notch will be found sensitive to touch. Pain of nasal ganglionic or sphenoidal origin will not be influenced by nasociliary cocainization. Ewing's sign will be absent. No pus will be found in the middle meatus. The supraorbital nerve will be negative to pressure. Pain of nasal ganglionic origin will be relieved by cocainization of the nasal ganglion. Pain of sphenoidal origin will not be influenced by any of the above procedures.

Clinical Course and Treatment.—My observation, so far, has been that nasociliary neuralgia has usually been a transitory phenomenon in the course of cases which have been under observation or treatment for something else. The nasociliary neuralgia would appear from time to time in the course of other clinical conditions and was usually not obstinate; it would yield to cocainization and applications of dilute carbolic acid, ½ per cent. Four times, however, I have seen it the only clinical phenomenon. Once I injected the nerve trunk at its entrance into the nose, with relief to the patient. The technic is that first advocated by Otto J. Stein in his alcohol injection treatment of hyperesthetic rhinitis. A straight needle is passed upward in the nose in the same way as the applicator for cocainization, described above. A few drops 95 per cent alcohol with 5 per cent phenol are instilled into the nerve trunk at its exit from the ethmoid slit.

XI.

VOCATIONAL, OCCUPATIONAL OR INDUSTRIAL DISEASES OF THE EAR, NOSE AND THROAT.

By John A. Donovan, M. D.,

Butte, Mont.

A correspondence with one or more otologists in each locality in North America shows that a few of our profession overemphasize this subject, while many more have hardly given it a thought. The recent war, as well as the increasing clamor for state medicine, makes it imperative that we consider it carefully. A general knowledge will also assist us in making a correct diagnosis in many an obscure case, especially in patients consulting us from other industrial localities. Besides one or two friends in each city, who have assisted me, to whom I express thanks, I have quoted liberally from H. V. Wurdemann, also from Kober-Hanson, and Barrett and Shaw's works on "Occupational and Vocational Diseases."

Though it may appear that all the diseases enumerated here are due to a vocation, such is far from the intention, for, except in those few very obvious special cases, the vast majority would not have resulted except for a very fertile soil being already supplied, such as diseased tonsils, adenoids, deflected septum, hypertrophied turbinates, or other abnormalities of tissue. Any of these conditions should always immediately receive special attention when the person contemplates a vocation which is likely to aggravate the condition, though no serious symptoms then manifest.

Not knowing a better method, I shall ask your kind indulgence, first, in considering general conditions and specific elements causing diseases, together with the symptoms of each. Then, under vocations, I will simply refer to these causes again to save your time. With few exceptions, no symptoms, except those to which this title refers, will be mentioned, the other general symptoms being assumed.

CAUSES.

1. Altitude.—In first visiting high altitudes most people experience a fullness in the head, a feeling of dyspnea, head throbbing with heartbeats, nose bleed, nasal turgescence, irritation and dryness of the throat, fullness (really a vacuum) in the ears, tinnitus, decreased hearing (really due to the closure of the tubes, and immediately relieved by inflation), and dryness of all mucous membranes. High altitudes are naturally very dry. Exercise, especially climbing, increases all symptoms. All these usually disappear in from a few hours to a few weeks' sojourn. A very rapid ascent to a high altitude intensifies all these symptoms. Besides there may be severe hemorrhage from the nose, gums and even the ears, with labyrinth and semicircular canal involvement, dizziness, nausea and even complete unconsciousness. This latter condition is more likely produced by a too rapid descent, and results fatally for the aviator (the cause of a number of fatalities).

Of course, cloud moisture, alternating with extreme dryness and intense cold, accompany extreme elevations. Fortunately people soon become accustomed to these minor changes and do not notice them. For example, in Butte, where thousands of men descend and ascend 3,000 feet, or even 4,000 feet, in the mines in a few minutes' time, I do not recall any miner ever mentioning this factor, while a stranger is fully conscious of a change. Of course the heat would be great at these lower levels, except for the constant supply of compressed air.

Caisson disease is in this classification. Men work in highly compressed air containers. Probably there is an excess of oxygen, and possibly injurious gases, dissolved under pressure in the blood; and if the air is allowed to escape too rapidly from the caisson this gas in the blood is released into the tissues; or it may be toxic or carbon dioxid; or again it may simply be from the sudden release of pressure. The results are: Epistaxis (very common), ruptured drum membranes, tinnitus, nausea, giddiness, loss of power in the limbs and unconsciousness.

Asthma, hay fever and similar conditions are usually relieved and very frequently permanently disappear in high, dry

altitudes. Hypertrophies, turgescence, tinnitus, etc., are probably made worse, but often the dryness improves them. Mucous discharges are lessened. Inversely, these chronic turgescent rhinitis, with ear complications, or dry or atrophic conditions, improve immediately on going to low, moist altitudes. I have had many patients with chronic discharging sinuses or ears report immediate relief on going lower, while a very few became worse by the change. We are about 5,800 feet elevation, dry, and never very hot. Contrary to the general opinion, a descending barometer is not the cause, in itself, of rheumatic conditions, as otherwise elevation would increase it also, which is not the case.

2. Winds and Drafts.—Fast motorists, all speed fiends and those living or working in high winds or drafts suffer from irritation of the nose and throat, with all the ear complications. A direct hard wind into the ear causes myringitis, otitis and, in time, chronic disturbances with deafness.

3. Temperature.—Constant extreme cold or heat do not affect like sudden changes. The extreme cold of the North Pole did not give Peary's men any colds, but opening a bundle of carpets, also cleaning house, immediately produced severe coryza in all hands. The modern girl, or rather her modern clothing, or lack of it, will not produce nearly the coryzas, rhinitis, laryngitis and ear complications from which her more or less fortunate sisters cooped up in overheated apartments will suffer. The overheated offices, theaters and Pullman cars in which the long suffering public is at the mercy of a janitor or colored porter cause innumerable catarrhal conditions and are the origin of too many fatalities resulting therefrom. It is the excessive heat, relieved by sudden cold drafts, or vice versa, that causes the trouble. Of course, local irritations, dermitis, perichondritis and effusions in the external ear, frost bites and gangrene of the ear result from extreme exposures.

Many a case of chronic laryngitis will soon disappear by sojourning outdoors. Living in a tent in the woods in winter is my favorite prescription for myself.

4. Humidity.—Humidity, according to Collis and Greenwood. Though in dry, changing air one may work at a temperature of 135 degrees F. without any immediate harmful

results, in humidity, when the temperature as measured by the wet bulb thermometer reaches 78 degrees F., the danger point is reached for carrying on active work. Body temperature is regulated principally by skin radiation, conduction and evaporation, which is prevented by a warm humid atmosphere. The maximum efficiency seems to be obtained in a relatively dry atmosphere at 65 degrees F., while after a day's labor inside, a humid temperature of 70 degrees F., the worker has no energy left and has no desire for food.

In dry places, mucous membranes dry and discharges diminish or cease. In dampness, mucous discharges become excessive. Rheumatism, and its sore throats, is common. Pharyngitis, tonsillitis and laryngitis are common in those working in wet places, also mycosis of the external ear canal, chronic congestion of all mucous membranes (these, of course, are aggravated by the sudden cooling at the close of day).

5. Dust.—Dust, except when fully exposed to sunlight and fresh air, usually contains infectious matter which is the cause of a great many of the infectious diseases of the respiratory organs, with the usual ear complications. Mechanically, there is a constant irritation of all the mucous membranes. The anterior part of the septum is irritated and bleeds easily, and there are small ulcerations and perforations. The posterior septum is swollen and dust covered. Ultimately there are hypertrophies of the posterior, especially the upper portion of the septum, the middle, and then the lower turbinates, functional collapse of the nasal tissue, loss of smell, taste, etc., dry feeling in the throat, engorgement of the large vessels, dusty mucous, glaring pharynx and many small hypertrophies, later loss of sensation and atrophy. The larynx shows similar reaction, ear complications as usual.

Most varieties of dust, ordinary dirt, smoke, coal dust, etc., will be coughed up and expectorated, so, if not exposed too long, will give but temporary symptoms. Every person with a deflected septum is an easy victim to dust irritation. Hard rock dust, included under the general term silica, remains permanently in the lungs, producing a fibrous condition known as fibroid phthisis, or silicosis, or pneumonoconiosis, in popular parlance "miners' con." With the exception of the constant use of water sprayed on the rock while working, nothing will

prevent this most serious malady. The underground miner cannot wear a mask at all comfortably, but the man outdoors might. In fact, it is at present his only salvation. Butte's 3,000 miles of underground tunnels are kept habitable and cooled by an abundant supply of fresh air and cold water, operating through the compressed air drills. Fresh air is blown in the mine through large canvas tubes. The former method—that is, the use of compressed air—carried too much moisture. Of course, there is still some dust, and considerable heat and moisture, so we do not recommend deep mines as an ideal health resort. Though in some mines chronic laryngitis is common, in ours it is extremely rare proportionately.

Dust causes hay fever and asthma in many, especially when loaded with organic matter from sweepings, such as flour, horse dust and the pollen of many plants, etc., but again, there is most likely to be a deflected septum and enlarged turbinates, adenoids or tonsils, making an ideal field for trouble.

Ankylostomiasis, in miners, does not appear to exist in America. It is a trematode worm disease with anemia and edema.

6. Chemical Irritants.—Arsenic dust is a very frequent cause of a low anterior septum perforation and often occurs without noticeable symptoms. It does not extend to the bony septum or high up. Aside from this, acne of the face, nose and ears (arsenic polk), boils, ulcers, nausea, vomiting, severe coryza, dry sore throat and hoarseness frequently result from living in rooms with arsenic colored wallpaper. This arsenic dust appears to result from bacterial action originating in the adhesive paste. Middle ear and auditory nerve affections may occur.

Aniline. Local ulcers of the skin and mucous membranes, with dermatitis.

Carbon. Chimney dust, smoke, tar, pitch, etc., are local irritants, coryza and not infrequently cancer resulting.

Carbon bisulphid. Peripheral neuritis, bilateral paralysis.

Carbon monoxid, dioxid. Diminished power of speech and hearing, dizziness, extreme headache, aggravated by exertion.

Chrome and bichromates. Eczema and erosions, skin ulcers with thick undermined edges. It attacks nasal septum similar to arsenic, rapid perforation.

Cement, lime, salt, soda and potash are very irritating to the septum, causing small ulcers, hemorrhages and perforations.

Gasoline, benzol and naphtha cause irritation, with slow necrosis, etc.

Iodin is a nose and throat irritant, causing tinnitus and double hearing.

Fumes and gases of acids, alkalies and many other substances are extremely irritating to all mucous membranes, many very toxic, with symptoms accordingly.

Lead. Blue line on gums, pale face, headaches, simulating brain tumor, tongue and lip tremors, interrupted speech, laryngeal muscle paralysis, tinnitus, auditory paralysis and double wrist drop. Lead poisoning occurs in upwards of 110 industries.

Manganese. Impulsive laughter, mental changes, monotonous voice.

Mercury. Pale face, sore painful mouth, bleeding gums, profuse salivation, difficult swallowing, yellow ulcers, foul odors; in chronic cases a peculiar copper color in the mouth and trachea, constriction of the esophagus, labyrinth deafness, auditory paralysis and necrosis of the bone.

Phosphorus. Skin pallor, intense pain in the lower gums, necrosis of the lower jaw (phosyjaw), pus, large glands, necrosis of the septum and possibly the ear bones also.

Platinum dust. Coryza, sneezing, hay fever from which those exposed can get no relief while vocation continues.

Zinc. Quite similar to arsenic.

7. Explosives.—In a paper, "Blasting Eye Injuries," read before the Section of Ophthalmology, A. M. A., 1905, Journal A. M. A., I pointed out that gunpowder has a rendering effect, while high explosives have a shattering effect. Much surprise has been expressed at the numerous ear troubles following the late war, when none occurred in earlier wars. The substitution for black powder of nitroglycerin, fulminates, trinitrate of tulol, etc., is the explanation. Though a detached retina but very rarely, if ever, occurs from gunpowder explosion and not frequently from dynamite, when a box of fulminate detonating caps explodes accidentally, by observation of the patients who were in close proximity, that detach-

ment is the rule. Thus by analogy the severe ear complications are readily understood.

A shot from an ordinary sporting rifle, gun or pistol, if near the head, produces a concussion in the ears, irritation and tinnitus. I have found that hot douches of considerable water will readily relieve this. The ears should be protected with paraffined cotton plugs or something similar. If the concussion from big guns or blasts is severe and the membrane ruptures, it follows the long head of the malleus. If infection follows, then suppurative otitis results, with its usual complications. If the shock is severe and rupture fails to occur, the shock is transmitted to the internal ear, with possibly small labyrinth hemorrhages, symptoms of tinnitus, and decreased or lost hearing. The high and low scales are markedly diminished, while the middle scale may remain normal. Fortunately, most cases practically recover. When they do not, degeneration takes place in the organ of Corti and the labyrinth, with possibly eighth nerve involvement. Of course, severe shell shock, a process complex, may produce central trouble causing deafness. The semicircular canals are involved, with loss of equilibrium, dizziness, etc. Hysteria may be the cause with a certain class of patients. Malingering is not under discussion here. With riflemen and shooters in general, a mild catarrhal otitis media is much aggravated—in fact, it is a forerunner of many of the symptoms brought on by exposure to these blasts. Nitroglycerin headaches result from its explosion in confined spaces in mines, etc.

8. Noise.—Here we differ widely, and your criticism is especially invited. To economize time, I shall be dogmatic and simply express my own conclusions after studying many diverse opinions. The constant irritating noises that drive one mad belong to the field of the neurologist, but do, of course, consume much valuable mental energy. Noises of high pitch, when constant, especially within small inclosures, or within close proximity, do produce deafness. This is transmitted directly through the sound conducting mechanism, and not otherwise, and can be prevented by protecting the ears directly from the noises. There is a destruction of the organ of Corti in severe cases, beginning in the nucleated cells, to the neuron, then to the vibrating mechanism and membranous labyrinth.

The canals may become involved, vertigo resulting. Within buildings hair felt covers and felt partitions reduce the noise very much. Something should be worn in the external ear canal also. Here again those afflicted with mild catarrhal tubes are the first to suffer.

I believe that deafness from explosions is due directly to concussion and not to noises.

9. Fatigue.—Fatigue lessens tonicity and resistance of the mucous membranes in the nose and throat, with resulting engorgement. It also decreases the power of smell, speech and hearing. Disinclination to work, or aversion to work, brings on fatigue much faster than real labor. Poor hygienic conditions, bad light, bad air and most of the aforementioned abnormal conditions produce fatigue more rapidly than well ventilated, well lighted surroundings. A vacation or temporary change of vocation lessens fatigue and produces general relaxation from strain and is a direct invigorator. In other words, take a vacation out of doors while yet you may, for the time comes soon when you will not be able to say where you will go next. Join the Boy Scouts on their camping trips.

10. Vocations.—Alcoholics, a common vocation of the past ages. Engorged nasal and pharyngeal mucous membranes, which in time become chronic. All abnormalities of the nose, throat and ears are made worse. A characteristic unsteady voice.

Authors. See office workers.

Auto drivers, exposed to drafts, nose, throat and ears, dust and gas, with the advantage of much fresh air.

Attorneys. See singers and office workers.

Aniline dye workers. Dermatitis and ulcers.

Aviators. See altitude. In addition they have exposure to high winds and cold, also to the intense constant motor noises, with resulting deafness if not protected.

Athletes. Septum hematoma, broken septum, ruptured drums, perichondritis (prize fighter's ear).

Artificial flower makers. See arsenic and office workers.

Band instrument makers. See soldering.

Balloonists. See aviators.

Boilermakers' deafness. See noises.

Blacksmiths with deafness, very rare, except in close inclosures or where many are working together.

Brass founders' ague, headaches. See zinc.

Brass and copper workers. Green lime on gums. See zinc and noises.

Button, horn and shell workers. Dusf very heavy, nose bleed, etc.

Brewers. Tuberculosis. See alcohol and humidity.

Blanket storing. Brimstone fumes very irritating.

Blasting. Powder headaches, deafness. See explosions.

Battery makers. See lead.

Bakers, confectioners, pastry cooks. Of their total deaths, one-third are due to diseases of the air passages and lungs. See dust and temperature.

Chauffeurs. See auto and carbon monoxid gas.

Cotton mills. See textile.

Coppersmiths. See noises and brass.

Cooks. Atrophy of taste and smell. See bakers.

Clergymen. Sore throats. See singers and office.

Color factory workers. See arsenic, soda, potash under cement.

Chimney sweeps. See cardon dust, cancer.

Canning factories. See humidity, wet and acid fumes from soldering.

Celluloid makers. Fumes from solvents, acetone, amylacetate, alcohol, ether and acids.

Chemists. See all chemical poisons and fumes, also office.

Cement and concrete workers. See cement and dust.

Chrome workers. See chrome poisoning.

Caisson workers. See altitude and humidity.

Divers and swimmers. Rupture of the tympanic membrane, acute infection of the middle ear from water entering the middle ear through the eustachian tubes, due to improper breathing.

Dyers. Soda, potash. See calcium, aniline, lead and arsenic.

Dentists. See office workers.

Electric generators. Deafness from noise, when cooling motors improperly installed.

Elevator boys. See temperature and drafts.

Explosive factory workers. Powder (nitroglycerin) headaches. See carbon monoxid and celluloid makers.

Engineers. See locomotive.

Farmers. See dust, temperature and humidity. See stockmen, tetanus, foreign bodies, foxtail, chaff and burrs in the external ear canal often remain a long time before they are noticed.

Fur pellers. Anthrax.

Flax dressing. Silicosis. See dust.

Flour millers. See dust and noises. (Millers' asthma.)

Fishermen. Dampness and cold. See temperature and humidity. Case of lymphoid growth in the tongue and epiglottis reported by Dr. C. H. Baker.

Fireworks makers. Argyria from breathing silver dust.

Garage workers. See chauffeurs.

Gas works. Carbon monoxid poisoning, and dust.

Glass blowers' mouth. Swelling from the angle of the mouth to below the ears and parotid glands. Thick patches of mucous membrane on the cheeks, tuberculosis from excessive heat. Syphilis from exchange of blowing tools.

Dictaphone. Hal Foster reports deafness. See telephone.

Gold milling. See dust, fumes, chlorin, cyanid and mercury.

Galvanizing. See arsenic, also mercury and zinc.

Gannister miners and workers. See stone cutters.

Hat felt makers. See mercury.

Horsemen. See stockmen, also athletes.

Indoor workers. See dust and noises.

Janitors. Hay fever. See dust.

Jute factory workers. Tetanus.

Lime workers, plasterers, etc. See cement.

Lead products manufacturing. See lead.

Leather workers. See tanners.

Lawyers. See office and singers.

Locomotive engineers. These have heretofore been erroneously placed with boilermakers. All authors and most of my correspondents so classified them. For many years I have taken care of all Northern Pacific employes operating trains across the Rocky Mountains; also the employes of the B. A. & P. R. R., the first electrified steam railroad. The mountain division is the hardest and most noisy portion of any railroad;

even rear coach passengers can hear the puffing locomotives, yet I have never treated a trainman for deafness that I could positively directly attribute either to the noise or vibrations.

President H. B. Smith and Secretary W. A. Laidlaw of the Northern Pacific Beneficiary Association report to me that a hurried search through several years' records confirms my observations. Through the courtesy of Mr. F. V. Whiting, attorney of their claim department, I was put in communication with the chief surgeons of the New York Central systems and the results were practically the same. A German authority reports that only 8 per cent of their locomotive engineers have normal hearing. If this is correct, then the protection given to their engine drivers must be of the medieval type. Trainmen on modern equipped American roads are of course somewhat, though not excessively, exposed to conditions producing catarrh but not to noise or concussion deafness. I am excluding boiler factories, of course. I have seen one case of deafness in an engineer who was very close to the whistle when someone pulled it; also one case of deafness from a boiler explosion.

Match makers. See phosphorus.

Match safety. See chromates and phosphorus.

Mirror makers. See mercury.

Manufacturers of scientific instruments. See mercury and chemicals.

Mechanics. See locomotive engineers, noises and dust.

Millers. See dust, noise and millers' asthma.

Miners. See dust, humidity, temperature, altitude and explosions. Job, chapter 28, is the first miners' textbook written.

Miners' nystagmus is not an ear, but an eye complication.

Mountaineers. See altitude. The high, dry air, filled with ozone and a superabundance of ultraviolet rays, stimulating and invigorating, is the salvation of thousands of catarrhal, emaciated, overworked people who can occasionally avail themselves of its advantages.

Musical instrument makers. See makers of band instruments.

Office and indoor workers. Professional, clerical, clerks, factory girls, needleworkers, seamstresses. I believe this class

supplies the head specialist his greatest number of patients, notwithstanding the fact that the authors have given it scant attention. G. W. Spohn in his letter feared he would be considered freakish for placing this occupation as the most hazardous in this special classification. I agree with him. A lack of outdoor physical exercise, poor air, overheated drafty rooms frequently filled with tobacco smoke, inappropriate diet, an excess of sweets and pastry, poor digestion and inactive bowels are all extremely conducive to edematous, sluggish mucous membranes, with a lack of tonicity, insufficient muscular strength in the pharynx, larynx and even within the ears. Catarrhal affections of the nose, throat and ears are the rule rather than the exception. When occasionally exposed to unusual atmospheric conditions, acute catarrhal inflammations immediately result, with tuberculosis, etc., following. Early appropriate treatment of nasal deformities, adenoids, tonsils and teeth will prevent the vast majority of these conditions.

Printers. Auditory nerve deafness, tuberculosis. See lead and vapors.

Plasterers. See cement.

Public speakers. See singers and office.

Pregnancy with some is accompanied by irritation and turgescence of the tuberculs of the septum (the genital area in the nose), paresthesia, and hyperesthesia of voice, smell and hearing.

Prize fighters' ears. See athletes.

Painters. See lead, arsenic and zinc.

Potters. See dust, silicosis and lead.

Physicians. See office. Liable to acute and chronic infections of the nose and throat, with sinus disease. Obstetricians, urologists and laryngologists exposed to syphilitic and tubercular infections, and Vincent's angina.

Power plants. See electric generators.

Porcelain workers. See chrome and lead.

Photographers. See office, soda, potash and chromes. Platinum dust from papers causes coryza and hay fever, sometimes very serious.

Powder makers. See explosions, gases and dust.

Rubber manufacturers. See carbon bisulphid and lead.

Rag grinders. See dust. Shoddy fever, severe irritation of all mucous membranes, with headaches.

Refrigerator and ice cream works. Chronic congestion (cold and moisture).

Syphilis. It is a disease affecting all vocations and avocations, but possibly more prevalent with those who are in close contact with the larger mass of the traveling public, society satellites, indoor sports, certain classes of rooming house, hotel and restaurant employes, physicians, especially obstetricians and urologists, nurses and wet nurses. My brief observation of the northern Indians was that they are extremely susceptible—in fact, it is very fatal amongst their younger women. Our present government regulations are a great help and, when efficiently administered, may ultimately eliminate it. Contrary to the prevalent opinion, the laryngologist sees the most cases; especially is this so with women patients.

Acute pharyngitis, chronic laryngitis, soft, soggy nasal growths easily broken down, perforations destroying the bone, with depression of the nose (not so with dust or chemical ulcers), laryngeal growths, loss of voice, deafness, cerebral troubles. Deep, dirty grayish diphtheritic appearing ulcers of pharynx, tonsils, palate and larynx, emitting a dirty dog odor, very characteristic, and when learned is almost a positive diagnostic symptom.

Stockmen. See farmers. Glanders, actinomycosis, anthrax, tetanus, foot and mouth disease ("aphtha fever"), vesicles and ulcers on the tongue, lips and pharynx (a long list of catalogued diseases officially designated, which very rarely happen), but foxtail beards (something like barley), burrs, etc., carried by the wind, frequently lodge in the ear canals, and sooner or later inflammation sets in. Though very frequently exposed to much wet, cold and severe high winds, etc. (excepting those with marked nasopharyngeal abnormalities and diseased teeth), they are singularly free of disease. A good diet of a reasonable allowance of that most nutritious, easily digested, stimulating food, good beef with vegetables, seems to build an immunity against the diseases we are here considering.

Seamstresses, needleworkers and dressmakers. See office. They seem especially prone to deafness.

Sheep tenders. See stockmen, and arsenic from sheep dip.

Soldiers. See explosives and syphilis.

Sailors. Mal de mer, an abnormal condition of the superior semicircular canals. See syphilis.

Slaughter house. Dampness, glanders, tetanus, actinomycosis, rheumatic throat, etc.

Subway workers. Carbon dioxid, iron dust, silicosis, drafts, temperature and moisture.

Swimmers. See divers.

Soldering. Fumes of acid produce intense pharyngitis, not infrequently becoming very serious.

Shoemaking and staining. Dust, aniline, lead, tuberculosis.

Sugar factories. The lymphatics from microorganisms, bone black dust, offensive fumes, catarrh.

Salt workers. See calcium.

Smeltermen. Arsenic, chlorine, bichromates, mercury, dust and chemicals.

Stone cutters. First in the list of vocations in percentage of tuberculosis mortality; silicosis, chronic diseases of all air passages and ears, followed by atrophy and laryngitis, etc.

Singers and speakers. Singers' cramp from fatigue in attempting to use the voice at too high a pitch or too great a range. Singing should not be done over one hour (two hours at the most) a day, and never over fifteen minutes (twenty minutes the extreme) at one time. There should be at least six weeks' vacation each year with no practice. Walking outdoors several miles a day is an ideal exercise and is absolutely necessary. Coughing to clear the throat when starting to sing induces hoarseness. Wear light woolen underwear in cold weather, no neck wrappings. No smoke, no dust.

Vocal nodules from excess or misuse of the voice. Laryngeal irritation affects the timbre of the voice. Too rapid training affects solidity. Vocal excesses diminish the compass. An emaciated condition, tuberculosis, etc., reduces the agility, also the intensity. Chest disorders reduce the medium scale. Catarrhal conditions, bad tonsils and adenoids diminish the clearness. Nasal abnormalities diminish the resonance. Neuropathic temperaments produce the nervous voice.

Speech fatigues more than singing. Public speakers should acquire and maintain a standard pitch, within the medium

tones, which does not produce fatigue. Start speaking with the voice where it is and allow it to gradually reach its proper acquired standard intensity. Chronic pharyngitis and clergymen's throat, also laryngitis, results from the neglect of the above rules. See office.

Trainmen. See locomotives and drafts.

Tunnels. See miners, caisson and subways.

Travelers. See heat, Pullman and syphilis.

Theaters. See heat and atmosphere.

Tea, tobacco, spice and perfume testers. Nicotine, thein poisoning and atrophy.

Tobacco. Tobacco factory workers rank second in tubercular deaths from tobacco dust in the throat. Smoke aggravates catarrhal conditions and tinnitus is intensified. Cancer of the lip, syphilis from exchanging pipes.

Teachers. See office. Much catarrhal inflammation, chalk dust, irregular temperature of rooms, loud talking, laryngitis and secondary ear diseases.

Telephone. Operators in the Bell and all other phones of low voltage appear to have no more ear trouble than any other office workers (contrary to all textbook authorities). High tension currents, acoustic bangs, ringing bell with the receiver in the ear, especially so in the higher voltage systems, does cause annoyance, and does irritate a sensitive ear considerably, but ordinary conversation does not. I saw one man who lost the hearing in one ear completely by lightning striking a wire. Proper fusing would have prevented this. Dr. C. B. Lyman and Dr. E. W. Collins of the Rocky Mountain Bell System report no serious trouble at all with any operators, but report complaints to be in direct proportion to the user's mental attitude toward the company.

Tanning, leather workers, taxidermists and furriers. Asthma, anthrax, chrome, lead, arsenic, mercury and dust.

Textile workers. See dust and noises. Dry throats, cereum plugs in the ears, mycosis of the ear canals.

Upholsterers and mattress workers. Erysipelas and infections from old rags and dust. See textile.

Wool sorters' disease. See anthrax and mycosis of the ear caanls.

Wallpaper. See arsenic

Wood polishers. See chrome and dust.

Wheel polishers and grinders. See silicosis. Stone cutters.

Washerwomen. Infections, syphilis, chemicals (lead and mercury) from clothing of workers. Catarrhal conditions from temperature and moisture, mycosis of the ear canals.

Weavers and spinners. Mycosis of the ear canals.

A very formidable list, notwithstanding the Irishman's conclusions that, after all, nearly everybody dies in bed.

XII.

TINNITUS AURIUM.*

By Thos. J. Harris, M. D.,

New York.

Allow me to express to you my grateful appreciation for the invitation to address you this evening. It is with no little hesitation, however, that I venture to present before so distinguished a body of specialists a paper on the subject which has been assigned to me.

Boston's contributions to otologic science, from the days of the late lamented Dr. Clarence Blake, are exceeded in number and quality by no city in this country. To contribute anything new on the subject of tinnitus aurium is beyond my fondest hope. All subjects, however, connected with our specialty are deserving of consideration from time to time, and it is with the thought that I shall only be opening the discussion that I have the temerity to draw attention this evening to some of the salient features of tinnitus aurium.

Some twenty years ago the writer had the privilege of reading a short paper on this subject before one of our national societies, in which an attempt was made to bring together the not very extensive literature. Since that time, apart from a number of interesting case reports, only three articles of importance, so far as we are acquainted, have appeared in English, one in 1904, by W. Sohier Bryant, which contains the most elaborate classification of the subject which we know of, and the others by H. O. Reik, in 1904 and 1912, both of which represent much careful and meritorious study.

Tinnitus aurium (noises in the ear), for the most part a purely subjective sensation, intangible and invisible, must always remain a phenomenon, impossible in many particulars of complete solution. For its intelligent consideration, some simple working classification is desirable. None is simpler than a division into two groups, subjective and objective, according

*Read before the New England Ear, Nose and Throat Society, March 12, 1921.

to whether the sound is heard only by the patient or by the observer as well, and again into two subdivisions, exaural and entotic, depending upon whether the sound arises outside or inside the ear. No symptom or condition arising in connection with the ear demands more careful investigation. A perfunctory examination is too often the practice. A faulty classification and prognosis is the result, with faliure in the majority of cases in the attempt at relief.

Tinnitus aurium is wont to be found in the course of almost every affection of the ear, although it is true that some of the most severe cases of disease of the inner ear have been free from it. It is especially common as an early symptom of otosclerosis, often before any loss of hearing can be detected. At the onset its location by the patient is vague or faulty, but in time he becomes able to state with definiteness the locality from which it arises. The character of the noise varies in the extreme. Often, it is not one noise, but a number of noises associated together. The intensity of the noise in the two ears is apt to vary, and conditions of the weather, dampness, etc., bodily and mental exertion, alcohol, menstruation, etc., are wont to have a marked effect. . The disposition of the patient also has much to do with the annoyance which the noise occasions. Some patients suffer so that they threaten to take their lives, while others apparently are little inconvenienced by it.

Cases of objective tinnitus are comparatively rare. The sounds may arise outside the ear and be loud enough to be heard at a distance. All of you have probably had cases of this nature. They may be vascular in character, arising from one of the vessels in the neck as demonstrated by digital compression, or muscular, due to the contraction of some one of the pharyngeal muscles. At times it is entotic, as for example, the sticky mucous sound which is occasioned by the physiologic act of opening the eustachian tube or the contraction of the tensor tympanic or stapedius muscles. Cases have been reported where this muscle contraction was voluntary.

Another group is tinnitus from reflex causes, as for example, from the trigeminal or facial nerve. Politzer speaks of a patient in whom rubbing the skin in the region of the ear would produce such a tinnitus. All of these noises are, for the most part, what we might call curiosities and do not

demand lengthy consideration. The great majority of ear noises are subjective. Of these a few are exaural, as from an aneurism or large vessel in the neck, and of these fully 80 per cent are entotic. These can arise in connection with and as a symptom, at some stage or other, of almost every form of disease affecting the sound conducting or sound receiving apparatus, and apparently, at times, independent of all disease. A noted otologist in this country has had tinnitus for many years without deafness. Apart from the actual disease in the ear itself, and as a direct cause producing the ear trouble, is some obstructive disease of the nose and throat. Too great emphasis cannot be placed on the close relation between disease of the nose and throat and tinnitus aurium. Only second in importance as an etiologic factor is some autoinfection proceeding from the gastrointestinal tract. A number of cases have been reported where the source of the infection was in the teeth. Blood dyscrasias, such as lues, high pressure, pyemia, are also a cause. Certain drugs, such as quinin, salicylic acid, as you are all aware,can give rise to noises in the ear.

Still another group is the cases of nervous tinnitus without deafness, occurring in highly nervous individuals, due to anemia, grief, etc. If the cause is not removed the tinnitus may continue through life, usually without the onset of deafness.

Finally, in this connection, should be mentioned the interesting group of cases which Bryant among others has called attention to, namely, the psychic group. Here the complaint is of hearing voices. Patients are either already insane or the hallucinations complained of are premonitory symptoms of insanity, although Politzer states that where ear disease is present treatment addressed to it can improve the hallucinations or even cause them to disappear.

Bryant's conclusions, in his interesting paper on the subject of tinnitus aurium and hallucinations of hearing, bear out this contention of Politzer. He states: "The hallucinations usually depend for their inception on stimuli received by the auditory center. The stimuli originating peripherally pass directly along the auditory fibers or indirectly from other centers along the association tracts. In rare cases the auditory center itself may be subject to primary stimulation, which is due to pressure or to chemical irritants." He adds that "tinnitus aurium is a

common accompaniment of auditory hallucination and is probably its usual exciting cause," and states "that the insane whom he had examined had chronic ear affection, which in all cases of recent insanity must have preceded the hallucinations of hearing. He concludes his article as follows:

"The evidence points out a logical connection between ear disease and hallucinations of hearing.

"In a susceptible, psychopathic individual, hallucinations may be excited by the irritation of subjective noises.

"Improvement or cure of the coincident ear affection may logically be expected to cause an improvement or cure of the auditory hallucination."

While Bryant's article is the most exhaustive on the subject with which we are acquainted, the relation between the ear disease and the presence of noises of the ear of the insane has long been known. The most famous instance of this is the musician Schumann, who, for a number of years before he was adjudged totally insane, used to hear strange voices. On one occasion he stated that he had heard the voices of Schubert and Mendelssohn, and as a result of this composed a selection in nine variations.

Just how subjective tinnitus aurium arises is not clearly understood. The usual view held is that it is due to increased labyrinthine pressure. This is satisfactory so far as the small number of cases having their origin in the inner ear is concerned. There is a certain number, as just stated, in which it is undoubtedly circulatory, transmitted from the great vessels of the neck, especially the carotid and the vertebral arteries, as shown by compressing these arteries. The larger group, however, is made up of cases of interference with the sound conducting apparatus. It is undoubtedly true that anything which serves to interfere with the escape of sound from the ear must needs increase it in intensity and so render it liable to be heard. Indeed one of the many wonders of the auditory apparatus is the marvelous way in which all entotic sounds are taken care of in health by the nervous system.

As opposed to the increased labyrinthine pressure theory is the view of Reik. Reik, as the result of a series of interesting experiments on dogs, showed that increase in the intratympanic pressure caused a vasomotor dilatation, resulting in a lowering

of the blood pressure. Based on these experiments, it is Reik's opinion that "Subjective auditory sensations generally result from vasodilatory changes in the vasomotor systems of the middle or internal ear, and may be caused by any case of irritation which will so affect the vasomotor nerves controlling these vessels. Consequently, that stimulation of vasomotor of the ear produces a depressor effect, small vessels become dilated and the abnormally large amount of blood coursing through this gives rise to new sounds to which the auditory nerve is unaccustomed. In corroboration of this view, Reik has demonstrated that persons suffering with tinnitus have a lower blood pressure than that which is considered normal for healthy individuals.

Downey carried out a careful series of clinical investigations under Reik's direction, which he reported to the American Otological Society in 1912. In this report he was unable to confirm Reik's observation of a uniform lowered blood pressure in cases of tinnitus. In certain cases he succeeded in benefiting the tinnitus by the use of the suprarenal gland extract. On the whole, however, the impression we get from reading his article is that its use was a disappointment.

Finally, so far as those cases of very severe tinnitus are concerned, there can be no question that they have their origin within the brain.

Prognosis. To a large degree the prognosis of tinnitus aurium rests upon the proper location of the cause. At the same time it must be said that no positive prediction should be made, favorable or otherwise, in advance of treatment. Before instituting treatment a most careful inquiry into every possible condition within and without the ear is called for. Of all conditions within the ear, none is so common as a swelling and obstruction of the eustachian tube, and no cases offer greater encouragement for relief than those where the cause resides here.

Treatment. It is Politzer's belief that inflation by his method is superior to that by the catheter to relieve this condition There are many cases, however, where neither bag nor catheter is sufficient and where it will be necessary to make use of gradual dilatation by means of bougies. Great credit is due to one who was until recently an active worker among you,

Dr. E. M. Holmes, for his perfecting and popularizing the nasopharyngoscope which bears his name. By this we have been able in recent years to recognize many pathologic conditions of the pharyngeal mouth of the tube. In our own hands direct treatment to the tube by means of this has far exceeded in value any other treatment which we have employed. Hand in hand with the treatment to the eustachian tube goes treatment to the nose and throat. Every one of you has had cases where relief of the tinnitus was promptly secured by removal of some obstruction or growth within the nasal chambers or in the nasopharynx, especially in the fossa of Rosenmüller. The same assiduous attention to the stomach and intestinal canal as well as to the tonsils and teeth is called for. We know of a case where the removal of a chronically diseased appendix cured the noise. In many cases the tinnitus gradually grows less as time goes on or the patient becomes more accustomed to it. This is particularly true in case of otosclerosis. Apart from the local treatment to the nose, throat and ear, much can often be accomplished by careful attention to diet, hygiene, etc. Alcohol undoubtedly increases the intensity of the noise. The same cannot be said of tobacco. Some years ago Reik carried out a series of experiments which showed that tobacco apparently had no effect upon the noise whatever. Internal medication is exceedingly variable in its results. Strychnin, in our hands, gives the best results. Iodid of potash we have used with benefit where the disease was located in the internal ear. Some most encouraging results have been obtained from the use of nitroglycerin. Bromide of potash and hydriodic acid we have repeatedly employed without satisfactory results. Reik, as a result of his experiments and deductions that there existed in all cases of increased intratympanic pressure a lower blood pressure, has employed the suprarenal gland with the view of raising the blood pressure. Used thus, the results were to him encouraging. This treatment has been curative or markedly beneficial in about three-quarters of all the cases, sometimes slow and only beginning after a period of delay. Possibly the effect of internal administration is cumulative.

Finally, so far as those severe and intractable forms of tinnitus are concerned which have their origin inside the

cranium, no ordinary method of treatment is of the slightest avail.

In such cases careful consideration of more radical procedures is in order.

Destruction of the labyrinth does not offer great encouragement. Duel in 1915 reported to the American Laryngological, Rhinological and Otological Society a case where he had twice operated on the labyrinth without relief of the noise.

Even the still more radical, and what would seem far more encouraging operation of destruction of the auditory nerve, has proved a disappointment.

At the Ninth International Otological Congress, held in this city in 1912, Mr. Milligan, Dundas Grant and Mr. Lake were all opposed to this operation, stating that they had nothing but failures from it.

Dench has reported a case of persistent tinnitus where he destroyed the auditory nerve with temporary benefit, but when last heard from the noise had returned. As a much less radical measure, Reik at the otologic congress in 1912 reported a case where he ligated first the internal carotid artery and later the common carotid with complete relief to the noise, and also reported that upon Halsted's recommendation he has placed a permanent metal band upon the carotid artery with equally good result.

CONCLUSIONS.

Our study of the subject leads to the inevitable conclusion that many phases of it still remain to be cleared up; particularly is this true of etiology.

Of the several accepted theories to explain the origin of tinnitus, that of Reik's seems the most plausible. It is easy to understand how any factor can cause a dilatation of the blood vessels and so an increased flow of blood through the ear. This does not need to be within the middle ear itself. It can reside in the external auditory canal, as for instance, a foreign body or impacted cerumen pressing upon the drum. Yet even this theory, plausible as it is, hardly serves to explain the many well known variations of noises in the ear. Why, if they originate strictly in the middle or inner ear, should fatigue or overeating increase their intensity? Why, in two persons suf-

fering from the same disease, should the noise be present in one and absent in the other? Or why, with no change in the objective findings, is the noise apt to become less intense as time goes on, if a vasomotor dilatation is present? Finally, the failures to relieve the noise by operations upon the labyrinth, or even by severing of the nerve itself, give us food for thought that its real source is not within the ear at all but in the brain itself.

So far as treatment is concerned, it is our feeling, as we have turned the subject over in our mind, that when we have failed to relieve it by attention to the nose and throat and the eustachian tube, together with such measures as may be necessary, addressed to the gastrointestinal canal, the outlook for therapy is not encouraging. We have spoken of success by means of drugs administered by the mouth; these cases undoubtedly are met with. We have taken occasion to inquire of Dr. Reik what his latest opinion is in regard to the use of extract of suprarenal gland. He did not hesitate to say that his early expectation had not been realized, although in a few cases he had gotten good results. Personally, we have had no experience with it. If the Reik theory is correct, it must follow that the use of a drug like this will have a beneficial influence, but operations, even such as loosening adhesions in the middle ear, cutting the tensor tympani, etc., and especially the larger and more extensive, such as cutting the auditory nerve, even if they give temporary benefit, are to be undertaken with great deliberation and only as a measure of last resort.

XIII.

POSTOPERATIVE TREATMENT OF THE RADICAL MASTOID OPERATION.

By J. A. Stucky, M. D.,

Lexington, Ky.

The topic as given to me by the Program Committee, to be considered in this symposium, would indicate that at least two other phases of this major surgical operation had been or were to be considered: 1. The indications for the radical mastoid operation; 2. The technic of the radical mastoid operation.

The postoperative treatment of the radical mastoid operation is of special interest to the surgeon because of the uncertainty of its duration, the annoying complications and results of neglect to patiently and perseveringly, almost daily for many days or weeks, treat the case, make it the operation to be most dreaded and avoided by the patient and otologist.

This is due to the fact that so many operators have had unsatisfactory results, even after long and careful treatment. As a basis for the after-treatment of the radical mastoid operation, it is assumed: 1. The operation was indicated; 2. A complete operation was done; 3. The tympanic orifice of the eustachian tube was closed, or so nearly so as to prevent retention of secretion and moisture in the middle ear cavity.

The two things that make any postoperative treatment uncertain as to time and results are: 1. An incomplete operation; 2. Neglect to so modify the bony and cartilaginous meatus as to produce the best facilities for drainage, ventilation and inspection, and failure to thoroughly remove the pathologic conditions in the different recesses of the middle ear cavity. The posttympanic space and eustachian tube are often a source of a purulent discharge and necessitate a protracted treatment.

Since my paper before this society, 1915, I have performed the complete radical operation on the mastoid in only a few cases, the modified operation as advocated then giving satisfactory results, except in cases where there was indication of extensive necrosis in the attic and mastoid process or intra-

cranial involvement. Postoperative treatment begins as soon as the operation is completed, the external wound sutured, cavity dried and inspected.

The healing of the external wound is much quicker and more satisfactory if traumatism of the surrounding area is minimized. The unnecessary use of a number of hemostats and the too forcible and long continued use of retractors may so lower the vitality of the parts, as a result of bruising and stretching, that union or healing is seriously impaired.

I have used the various antisepticizing solutions in the operated area, during and after completing the operation, but none has given me as uniformly satisfactory results as a 1 to 1,000 solution of alphozone. This powder is readily soluble in water, is thoroughly antiseptic, nontoxic and does not interfere with the blood clot when this is used in the classical mastoid operation. This remedy is made of succinic acid and hydrogen peroxid and is said to be "as germicidal as mercury bichlorid, 75 times as germicidally powerful as carbolic acid, 100 times stronger than formaldehyde," etc., but the solution must be freshly prepared, as "when dissolved in or on contact with water alphozone combines with a portion of the water and undergoes a change known as hydrolysis."

Satisfaction or success in the postoperative treatment consists in rapidly obtaining and maintaining a dry cavity, covered by a vascular fibrinous dermatized membrane.

The completeness of the operation and refinement of technic has much to do with attaining this end, but notwithstanding the thoroughness of the operation and perfect surgical technic used, neglected after-treatment will result in disappointment or failure of the operation.

In some cases it is most difficult to keep down granulations, and granulations decrease hearing, especially if allowed to form on the internal wall.

The first dressing consisting of a folded strip of gauze, which had been saturated with 5 per cent iodoform emulsion and so applied through a large speculum as to touch every part of the cavity and tight enough to prevent any sagging of the fibrocartilaginous wall or contraction of the external auditory meatus; at the same time care must be used to pack evenly

but not forcibly—the latter may result in interference with free circulation in the soft parts or displace the flaps made from the fibrocartilaginous canal.

The external dressing, consisting of pads of folded gauze wet in the 1 to 1,000 alphozone solution, snugly fitted around the external cartilaginous ear, over this absorbent cotton is applied and held in place by a bandage. This external dressing is allowed to remain for at least 48 hours, when it is removed and a similar but lighter dressing is applied. The packing in the cavity is not removed for four or six days after the operation, and this must be so carefully done as not to cause pain or bleeding or interference with the firm union of the fibrocartilaginous flaps.

The cavity is not irrigated but thoroughly dried with absorbent cotton, and again packed with 5 per cent iodoform gauze. In the second dressing I do not use the iodoform emulsion. At this time the sutures are removed and folded gauze placed over the posterior wound, held in place by the bandage. Best results have been obtained by rapidly reducing the amount of external dressing and doing away with the bandage—both are uncomfortable and retain too much heat and moisture. The wire screen mastoid protector devised by me some years ago, Fig. 1, I find most satisfactory and enables me to do away with the heavy dressing and bandage on the fourth or sixth day after the operation. After the second packing is removed from the cavity, which is usually on the sixth or seventh day, no further packing is used unless there is sagging or prolapsis of the metal flap, but instead the entire cavity is filled with powdered boracic acid and alphozone (six parts boracic acid to one part pulverized alphozone), two or three times a day, until the cavity is thoroughly dry and covered by a vascular fibrous membrane. For two or three days after beginning the use of the boracic acid and alphozone there is quite a free discharge of seropurulent or serous fluid, which fills the bowl of the external ear. This is removed with sterile cotton, the middle ear cavity dried with the same material by means of an applicator. The object being to keep the cavity as free as possible from heat and moisture, covered with the powdered boracic acid and alphozone, thoroughly ventilated and protected from infection.

Slow recovery, elevation of temperature or postoperative fever I have found to be more frequently due to absorption of proteids or toxins from the intestinal canal and not from sinus thrombosis. Most cases requiring the radical mastoid operation are more or less septic—the vitality and power of resistance is far from normal and to this condition we are to add the results of the anesthetic plus the operation.

It must be remembered that in septic conditions food not digested and assimilated thoroughly deranges the body chemistry, fermentation and putrefaction go on.

Ordinary bowel movement may remove some of this, but an empty alimentary canal does not mean a clean one; peristalsis is imperfect and the result of food putrefaction, and small particles of fecal matter remain in the folds and pockets of the canal, which give rise to toxins which easily find their way into the blood and lymph stream. For these reasons, immediately after the operation the patient is kept comfortable for at least 24 hours; usually the administration of one hypodermic of 1/12 or 1/8 grain of heroin will accomplish this. Free purgation, restricted diet (protein free), daily bath and gentle massage, fresh air, sunshine and rest.

The method I have outlined briefly is the treatment I have followed almost exclusively for the past eight years, because of the satisfaction given. The cavity is dry and dermatized usually in from three to six weeks.

Other methods, such as skin grafting, blood clot, bismuth paste and paraffin, etc., in my hands have not been satisfactory.

XIV.

TIC DOULOUREUX IN RELATION TO LATENT MAXILLITIS.*

By H. B. Lemere, M. D.,

Omaha, Neb.

Tic douloureux or trifacial neuralgia is characterized by sharp stabbing pains of intense severity, sometimes accompanied by facial spasms. The pain is usually referred to the distribution of the different terminal branches of the fifth nerve. An attack usually consists of several of these poignant, excruciating shooting pains, each short in duration and repeated at varying intervals. These stabbing pains may last for one-tenth of a second or more, or be in the form of an intense pain lasting as long as fifteen minutes, the average duration is less than a minute. The pain is entirely distinct in its characteristics from the pain resulting from a toothache or the ordinary supraorbital or infraorbital ache commonly called neuralgia. A pain that is continuous and throbbing in character cannot be classified as a tic douloureux. An acute sinusitis pain has no relation to trifacial neuralgia. The facial spasm is not a true motor tic which is purposeless, but is of the nature of muscular spasms elsewhere which accompany pain. It may be entirely absent, and replaced by the immobility of the face, or by the patient rubbing the face or by other forms of reaction to the pain. The attacks may occur at frequent intervals during the day or perhaps be several months apart. They rarely occur at night. Women and men are about equally liable, and either side of the face seems equally susceptible; over 90 per cent of cases occur after the age of 40, and 65 per cent of these between the ages of 50 and 70. Hugh T. Patrick gives the ratio of incidence as follows:[1]

The first or ophthalmic division is affected in 8.5 per cent.

The second or superior maxillary division is affected in 49 per cent.

*From the Otological Department of University of Nebraska College of Medicine.

The third or inferior maxillary division is affected in 25 per cent.

Two or more divisions are affected in 17.5 per cent.

The clinical observations of the older writers attributed the neuralgia to anemia and to rheumatic, gouty and neuropathic predispositions or conditions. These general conditions we now generally find depending on a focal infection as the underlying cause. Patrick,[1] however, in his excellent article on the symptomatology of trifacial neuralgia, from which most of my statistics are quoted, states that, "In no case have I known treatment of a sinus or tooth infection or the extraction of carious or painful teeth to cure trifacial neuralgia," and he gives as reference Hajek's experience, that he had never seen tic douloureux in sinus disease. Patrick's article is based on the careful observation of 200 cases and, as no general or local condition is found as a causative factor, the deduction would seem to indicate an idiopathic etiology.

I recognize the weight that the opinion of such careful observers carries. Yet there have several years elapsed since the above statements were made, and the authors in considering the modern conception of the pathology of the nose and of the alveolar processes probably might revise their etiology if they were to write at the present time.

In the literature of the past ten years Beck[2] finds but three references to the pathology of trifacial neuralgia in which the writers have also been workers.*

Such profound pathologic changes as these represent, however, the terminal stage. The exacerbations of pain are probably caused by vasomotor reactions within the nerve sheath and ganglion and their effect increased by surrounding osteitis.

It seems to me that a neuralgia of this type is unlikely to originate of itself, and that it is worthy of careful study to

*Postmortem examination of cases "that gave a history of long standing socalled severe face neuralgia show a definite shrinkage of the ganglion and its trunks. They appear paler than normal. Microscopic evidences are of a chronic neuroglia interstitial neuritis. The blood vessels are smaller. It appears as though the nerve was being starved of blood and is crying out for food instead of showing evidences of engorgement, which no doubt existed when the process first began and still does at certain periods of acute exacerbation."[2]

determine whether trifacial neuralgia is idiopathic and primary, or whether it is secondary and due to local osteitis of the bone surrounding any of the terminal branches of the three divisions of the nerve. On this will depend the rationale of the treatment. If the neuralgia is primary, then attacks on the nerve are indicated; if it is secondary, the primary osteitis should receive first surgical attention in the hope that the nerve may return to normal, and that the general conditions resulting from the osteitis, viz., anemia, rheumatism, neurasthenia, etc., may also disappear. This latter will be a real cure with a return to normal. Any procedures which rely on a deadening or killing the nerve result at the best in only symptomatic relief of pain.

Adson[3] agrees with Patrick that nasal and dental surgery do not help this neuralgia. He says:[4] "The true case of trifacial neuralgia has never been relieved by sinus drainage nor by the removal of the teeth."

The accepted operative procedures among neurologic surgeons, according to Adson,[4] are as follows: Deep alcohol injections into the peripheral branches and ganglion, avulsion of the peripheral branches, or division of the posterior sensory root of the Gasserian ganglion. For this last operation he has devised an extremely delicate and exact operation. Pleth[5] reported several cases of keratitis resulting from injections of alcohol deeply into the Gasserian ganglion, and in one case there was loss of the eye. He recommends cervical sympathectomy.

Flint physiology, 1895, agrees with the modern surgical findings that if the nerve is divided posterior to the ganglion the nutritional nerves from the sympathetic to the cornea are intact. The cornea is, however, anesthetic and there is no muscular reaction of the lids to protect the eye from foreign bodies or trauma. The cornea is, therefore, liable to traumatic injury and infection which may result in blindness from opacity of the cornea or from loss of the eye.

A consideration of the following facts leads me to the conclusion that there is perhaps a very definite cause for these neuralgias.

The fifth nerve differs from other sensory nerves in the fact that its peripheral branches pass through bony canals in bones

which are particularly liable to osteitis. The clinical findings show that each branch is attacked in proportion to the length of the branch so surrounded by bone, and also in proportion to the liability of the surrounding bone to inflammation.

The first or ophthalmic division of the fifth is the division least subject to attacks of tic douloureux. The frontal bone is not so frequently the seat of osteitis as the maxilla and the mandible, as the frontal sinus is much less liable than the antrum to chronic infections, and the frontal bone is removed from dental caries. The supraorbital branch runs through the supraorbital foramen, which has practically no length, and is often only a notch, so that it is surrounded only a ring of bone and has no canal.

The second division is the most frequently affected, and its infraorbital branch most subject to attacks of neuralgia. This branch passes through the infraorbital canal and groove and is surrounded by the bone forming the superior wall of the antrum for the entire length of that wall. The anterior terminal of the canal is the infraorbital foramen which emerges from the anterior wall of the antrum.

My findings in the examination of different specimens taken from both the anterior and the nasal walls of operated antra, show that generally there is a rarefying or a sclerosing osteitis accompanying a low grade or latent antrum infection. Added to this, the antrum is probably, of all the nasal sinuses, the one most frequently the seat of chronic infection. If to this factor is still further added dental pathology, the superior maxillary bone is seen to be particularly vulnerable to infections causing osteitis.

The inferior dental branch of the third division also runs through a long bony canal in the lower jaw, but as this bone is removed from nasal infections, and as the osteitis has to extend some distance from the alveolar processes to reach the canal, this branch escapes more often than does the infraorbital nerve.

Osteitis surrounding the different canals occurs therefore in about the same order of frequency as does the neuralgia, attacking the different branches. (See previously quoted table.)

The chronic osteitis and the neuralgia also both occur during the same period of life. They are least frequent in the first three decades of life, more frequent in the fourth and fifth, and most frequent in the fifth, sixth and seventh. Therefore, pathologically, anatomically and chronologically, trifacial neuralgia is closely associated with osteitis in the bones through which the terminal branches of the three divisions pass.

If these deductions are correct, the question resolves itself into treatment of the osteitis. Modern oral surgery is taking care of dental infections by partial or complete alveolectomy when neecssary, thus removing not only the offending tooth, but also the affected cancellous bone surrounding it. It remains for rhinologists to fill in the missing link by diagnosing and taking care of the osteitis resulting from either manifest or obscure antrum infections.

Tic douloureux is an extremely severe and persistent condition, and if attempts are made to relieve this condition by merely correcting nasal deformities these attempts will result in failure. Chronic infective processes come under an entirely different classification, and whether in the nose and mouth or elsewhere, should receive careful consideration. The surgeon, whether he be neurologic or rhinologic, must take them into account or his patient will inevitably suffer for his neglect.

It is useless to expect that removal or cautery of the turbinates or correction of nasal deflections will materially affect the condition of latent maxillitis except in so far as they indirectly improve the drainage of the antrum. This indirect effect, however, is not sufficiently reliable to be of much value in dealing with a chronic antrum involvement.

A latent maxillitis has certain unmistakable signs. They may all be present or only in part. They are:

1. Mucopus in the middle fossa. This mucopus is not necessarily yellow and creamy. It may be only scant and dry, forming a glazed scab covering the middle turbinate. Many latent streptococcus infections of the antrum give only a slight amount of clear, often glairy secretion. The maxillary opening and contour of the middle nasal fossa may be such that the infected secretion is not seen in this fossa but drains posteriorily into the nasopharynx.

2. The posterior pharyngeal wall usually gives evidence of the infected secretion, either by the lateral swellings posterior to the posterior tonsillar pillars, by follicular swellings covering the oropharynx, or by a dry glazed film covering the pharyngeal wall, or by masses of frank mucopus seen coming into view from above the uvula.

3. The middle turbinates are often granular on their anterior portion and there are sometimes polyps.

4. The density of the X-ray shadow is controlled by several factors which may be present.

(a) Osteoporosis or osteosclerosis.

(b) Osseous changes from concurrent alveolar diseases.

(c) Contents of the antrum. Thick mucopus producing a dense shadow, scant streptococcic secretion intensifying the shadow hardly at all.

(d) Thickness of the lining mucosa and presence of polyps.

When these underlying conditions are considered, the interpretation of the X-ray plate will give definite and reliable information. The shadows will have varying intensities, which I think can best be expressed by + signs, four plus being a practical opaque antrum and the other shadows grading down to a slight cloudiness, which is called one plus. If the cloudiness is still more indefinite, it may be recorded by an interrogation mark. Some antra with only faint X-ray showing have been the seat of latent streptococcus infection.

It is conceivable that an infection of the antrum with an essential atrophy of the mucous membrane and rarefaction of the bone might even appear clearer than normal. I have seen clinical evidence of this assumption, though I have never operated on such a case.

I attribute what success I have had in the following cases to through and through drainage, according to the technic I have previously described.[6 7 8] Unless it is understood that these latent or obscure maxillites so often do not necessarily consist of a frank empyema, there will be difficulty and failure in the diagnosis. It seems to me that the failure to recognize these low grade infections, and to provide relief, is responsible for the statements of neurologists and neurologic

surgeons that nasal surgery is powerless to relieve tic douloureux.

As these cases of latent maxillitis are diagnosed and given through and through drainage in the treatment of tic douloureux of the second branch, I believe there will be less need of radical procedures on the Gasserian ganglion or its root.

Following are three case reports:

Case 1.—Aug. 25, 1919. Mrs. A. G., age 60. For past ten years has been subject to severe headaches and nervousness. Has been pale and had poor appetite. Two years ago she had sharp stabbing pain in the region of the left cheek. For past six weeks has had these attacks daily, each attack lasting about one minute. During this period patient has refused to eat, fearing to bring on an attack. She has lived on liquid nourishment. Examination: Teeth, none filled or crowned. No pyorrhea. Nose: Middle turbinate swollen. Scant catarrhal secretion. Pharynx: Scant dry film of mucopurulent secretion. X-ray: Teeth vital and sound. Right antrum clear; left antrum, + + +.

Conclusion: There is a trifacial neuralgia, increasing in severity, confined to the second division of the fifth nerve and most active over the infraorbital distribution. The primary cause is a low grade chronic infection of the maxillary antrum (latent maxillitis).

The left antrum was opened according to the author's technic[6] and through and through irrigation carried on for two weeks, when the patient returned home, eating normally and feeling well. At the time of operation ten minims of alcohol was injected into the infraorbital nerve. There was no accumulation of pus in the antrum. The anterior wall was thickened but very soft, and the mucous membrane of the antrum was thickened and pale and had adherent scant mucopus.

April 22, 1921. Twenty months after operation the patient's general health and appearance were excellent. She had had no return of her neuralgia except this March, when she had several attacks during one week. These attacks seemed to be coincident with an acute reinfection in her antrum. The opening beneath the inferior turbinate is now found to be free and a large sized eustachian catheter was used to wash out

the antrum. The return was clear except for some flakes of mucopus. The next day the antrum was found to be entirely clear, and the attacks disappeared.

Case 2.—Mr. G. C. M., age 50, has had spasmodic, sharp, shooting, excruciating paroxysms of pain in region of left infraorbital branch of fifth nerve for past ten years. Attacks have been weeks apart, and last year had no attacks; five months ago had the flu, and since then has had attacks almost every week. In each attack the spasms came on every four to six minutes and lasted about an hour. The patient was very anemic and had been reduced to an extremely feeble state with marked nervousness. It was with difficulty that he could muster up courage to come up for examination, and he had to be supported on either side when he walked. He stated that he had sought relief and had been told of the operation for cutting the posterior nerve root, but had declined it on account of the possible after-results to the eye and to sensation.

Examination.—Nose: Both middle and inferior fossæ on both sides show slight mucopurulent secretion. No pure pus. Teeth: No alveolar trouble. Some pyorrhea. Pharynx: Glazed film of mucopurulent secretion. Tonsils: Lt., N.; Rt., +. Ears: Rt. canal filled with pus; Lt. memb. tymp. slightly reddened; no discharge. X-ray: Both antra cloudy. + + Sphenoids? Other sinuses clear. Rt. mastoid sclerosed; Lt., normal.

Both antra opened. Bony anterior walls very much softened. Bone and antral mucosa bled freely. No retention of pus in either antrum; mucous membrane in both showed softening and thickening resulting from pyogenic infection. Alcoholic injection of left infraorbital branch ten minims.

The writer's technic and after-treatment was followed with uneventful recovery. The patient returned home in about two weeks in good condition. Patient returned to Omaha in two months and reported doing a full day's work on the farm, which he had not been able to do for years. He had gained in weight and was robust and strong and his anemia had disappeared. He had a slight attack of neuralgia this spring, probably due to an acute reinfection of his antrum, but he

reports his general health as being excellent with no further attacks.

Case 3.—Mr. D. F. C. December 8, 1920. Age 63. Referred by Dr. G. A. Young, with diagnosis of trifacial neuralgia of infraorbital branch, left side. Patient, a robust man, says he has been suffering from attacks of neuralgia with sharp excruciating spasms for the past two years. Have been so violent for the past three weeks that he has lost sleep and has an extremely drawn and worn expression.

Examination: Scant dry bloody scabs and mucopus in left middle nasal fossa, mucus in right middle nasal fossa. Tonsils: +. Teeth: Several stumps above and below. Pharynx: Seems clear. X-ray: Rt. antrum, +; other sinuses, +; Lt. antrum, +; other sinuses, +.

Dr. Young advised draining the antra. Operation: Ether, both antra opened. Bony walls on both sides seem to cut normally. On opening the antra the mucous membrane was found thickened and covered with adherent slimy, foul smelling, transparent secretion. The author's technic was followed at operation and for postoperative treatment. The dental stumps were extracted. The patient had a slight twinge of pain the first two days, but no paroxysms. He made an uneventful recovery and returned home in about two weeks, having had no further pain. He reports at writing of this paper as being in excellent health and has had no return of his neuralgia.

My conclusions are as follows:

Treatment of the maxillitis is the operation of choice because

1. It removes a dangerous focus of infection.

2. It preserves the function of one of the most important cranial nerves.

3. It safeguards the eye against ulceration of the cornea, as a cornea that is anesthetic is particularly liable to injury, even with the operation of the posterior sensory root, which leaves the sympathetic fibers of the ganglion intact.

In the treatment of tic douloureux we are dealing with a persistent condition, and therefore I present these cases merely as a preliminary report, as enough time has not elapsed to judge as to the permanency of results. I trust that in the future observations of others may be added as to the relationship of chronic maxillitis to tic douloureux.

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XV.

DICHLORAMIN TREATMENT OF MASTOID WOUNDS.*

By Ralph A. Fenton, A. B., M. D.,

Portland, Ore.

Otologists have long beaten about for methods of treatment of the mastoid wound which would abridge the duration of the healing process and the pain of dressings. Perhaps this summary of results in some recent cases may be of assistance to those who are not in permanence committed to older methods.

During 1916-17 the writer made intermittent use of chlorazene, in powder and in various weak solutions, with variable success. Dakin's solution was not available in proper form in hospitals at that time, and some dermatitis was noted, perhaps from too great chlorine concentration.

There was not much mastoid work in the advanced evacuation hospitals at the American front in 1918; but in the surgery of battle injuries of the face and head much experience was gained in the management of extensive lesions of cranial bones by chlorine disinfection. Methods of protection to uninvolved skin and minutiæ of administration of the Carrel-Dakin solution were quickly assimilated in the crowded dressing rooms behind the lines, in spite of failure of the Medical Department of the Army to give training in this technic before officers left the United States for France.

Three serious objections to Dakin treatment of head wounds were: Difficulty of retaining tubes in place; ineffectual flushing of tubes by busy nurses, and difficulty of avoiding maceration of the skin by aqueous chlorinated solutions. In war practice, however, these objections were far outweighed by the immediate cessation of bacterial activity and the very rapid healing. Late in the campaign, when primary suture after

*Read before the Pacific Coast Oto-Ophthalmological Society, eighth annual meeting, Seattle, July, 1921.

total excision of damaged tissue was at last being adopted from the French technic by many American surgeons, conservatism had to be maintained in head cases for cosmetic and functional reasons. But perfect results in selected cases reminded one of the perfect results in the "bloodclot" mastoids of Reik—an almost parallel surgical procedure.

Dichloramin-T in oily media was used in the A. E. F. wherever it could be had, especially in 1 to 4 per cent solutions in eucalyptol, for bony sinuses and fistulæ not susceptible of treatment by the aqueous solution. Eucalyptol was preferred by the orthopedists as a solvent because of its low specific gravity and high penetrating power in long channels. The eucalyptol solution was readily injected by means of tubes.

It was found that in applying oil-soluble dichloramin-T to the relatively shallow mastoid wound, however, the eucalyptol solutions often leaked out of the tubes or the suture line, or might even be smelt or tasted arriving in the throat via the eustachian route. Dichloramin treatment being different in principle from antiseptic treatment, this loss was deemed undesirable. Dichloramin makes human cells unpleasant food for microorganisms, and must therefore be present in a wound until the microbes stop multiplying. For this reason we have preferred to use chlorcosane as a solvent. This heavy, viscid hydrocarbon oil has been chlorinated so that it will freely take up dichloramin-T if slightly warmed. Its viscidity is such that it will not readily flow into small tubing.

The technic employed in these mastoids, which was modified from that followed in other lesions of cranial bones of traumatic origin, is as follows:

The bone cavity is mopped dry and oozing controlled. Two silkworm gut sutures close all but the lower fourth of the skin-periosteal wound. With a medicine dropper two per cent dichloramin-chlorcosane solution is now injected into the antrum and allowed to fill the wound. A few centimeters of narrow selvedged packing is soaked with the oil and placed in the skin opening, as a plug to prevent the wound contents from escaping, unless inflammatory pressure arises. One end of the oiled packing is spread along the incision. Another

short oiled wick is carried through the external canal down to the membrana tympani. It should be clearly understood that these wicks should be very lightly inserted—never packed tightly—except of course where tight rolls are used to control sinus hemorrhage.

The wick in the ear comes out twelve to twenty-four hours after the operation and is not replaced. The canal should be kept dry by frequent swabbing with dry cotton. Dichloramin should not be used there any more because of the possibility of dermatitis in those cramped quarters.

The packing behind should come out in 48 to 72 hours (unless septic temperature indicates prior release of pressure by suture removal, moist applications, etc.) The wound will commonly show no more pus, but merely a bloody mucoid secretion, often somewhat scanty in comparison with that found at operation. The chlorine odor will replace the usual bloodclot or saprophytic stench.

Second and following dressings, made every day and later every third day, are done by very lightly swabbing out the wound with soft sterile cotton swabs, finishing with one or two swabs soaked in dichloramin-clorcosane. This is painless unless the skin edges are shoved apart. Half to one cubic centimeter of the oil should be dropped into the cavity as long as space exists, but oil should not be allowed to remain on the skin surface. This is the greatest cause of dissatisfaction with this agent; in sensitive skins erythema and dermatitis may be avoided by covering with a good zinc oxid ointment with mineral or lanolin base, and also by 50 per cent alcohol moist dressings.

Forty-five mastoids, in forty-three cases, have been tabulated in this study; all but two are "simple." (The detailed tabulation as exhibited at Seattle appears in the Transactions of the Pacific Coast Oto-Ophthalmological Society for 1921, including dates, initials and other necessary data from November, 1919, to June, 1921.)

Mastoids 1, 14, 15, 18, 27, 34, 35, 36 and 37 are excluded from totals regarding this technic because of general or local

complications ranging from erysipelas and measles to pneumonia. The following averages are found in the remaining 36 cases:

Duration of postoperative temperature	2.8 days
Stitches removed after	4.0 days
Pus gone from wound after	4.8 days
Discharge gone from ear after	3.3 days
Left hospital after	6.4 days
Left hospital (33 cases excluding scarlet, erysipelas and cardiac cases) after	5.2 days
All moisture gone from wound after	16.0 days
Wound healed (smooth, painless, no scab) in	25.5 days

It will be noted that the length of time for pus discharge from the wound and for hospital and office dressings is very considerably reduced from that of the older methods with antiseptics and repeated packing. This technic of dressing is less difficult, and is practically painless to the patient, although it should be guarded against irritative phenomena. Plugging up a wound with oiled gauze or sewing it up tight around a tube may seem radical to those unfamiliar with the principles of chlorine treatment; but the results are so agreeable to patient and surgeon that it is hoped others will try the method out. Results will speak for themselves.

616 Journal Building.

	Date	Initials	Age	Sex	Temperature	(days postop.) Stitches out	Pus gone from wound	Discharge gone from ear	Left hospital	Discharge gone from wound	Wound healed, dry, no scab
Case 1.—	11/13/19.	P. P. J.	38	M	14	4	3	2	....	6	....
Case 2.—	11/23/19	R. R.	14	F	6	4	4	3	20	24	32
Case 3.—	12/30/19	R. H.	22	F	1	3	2	2	6	18	32
Case 4.—	1/ 6/20	I. L. G.	24	M	2	5	7	2	4	10	30
Case 5.—	1/ 8/20	L. W.	71	F	11	2	3	18	17	22	35
Case 6.—	1/15/20	E. K.	21	F	2	4	5	4	5	14	20
Case 7.—	2/25/30	B. J. K.	60	M	3	4	12	4	4	20	36
Case 8.—	3/ 1/20	B. D.	10/12	M	2	4	4	2	2	11	19
Case 9.—	4/ 9/20	C. A. J.	35	M	0	4	4	2	3	10	17
Case 10.—	6/18/20	G. V. W.	12	M	2	16	6	2	3	14	16
Case 11.—	6/21/20	T. B.	12	M	1	3	7	3	6	10	21
Case 12.—	7/ 7/20	E. W.	12	M	0	2	2	3	2	8	24
Case 13.—	8/ 4/20	P. C.	22	F	1	3	5	3	7	14	24
Case 14.—	8/16/20	E. B.	25	M	2	5	8	4	7	30	45
Case 15.—	9/16/20	H. N.	4	M	3	4	4	7	5	....	....
Case 16.—	10/22/20	H. J.	7	F	3	2	4	6	7	18	20
Case 17.—	11/20/20	M. L.	15	F	3	4	4	3	3	14	24
Case 18.—	11/25/20	C. K.	2	M	3	2	4	4	3	90	90
Case 19.—	12/ 4/20	K. J.	18	F	2	4	5	3	4	16	23
Case 20.—	12/ 9/20	A. H.	18	F	2	4	3	2	6	20	31
Case 21.—	12/20/20	G. S.	8	F	4	3	8	5	21	18	20
Case 22.—	12/30/20	D. P. M.	23	F	7	2	3	2	10	9	10
Case 23.—	1/13/21	C. M.	6	F	2	4	4	2	5	11	29
Case 24.—	1/14/21	H. N.	8	F	2	3	7	6	4	24	38
Case 25.—	1/21/21	F. F. S.	46	M	1	6	4	6	6	19	22
Case 26.—	1/21/21	J. K.	2	M	0	4	3	1	4	16	20
Case 27.—	1/17/21	G. B.	rt. 3	M	28	3	31	26	10	43	44
Case 28.—	1/21/21	G. B.	left	....	28	2	5	4	4	16	26
Case 29.—	2/ 4/21	C. M.	7	F	7	4	5	2	4	22	32
Case 30.—	2/ 7/21	J. P.	7	F	3	4	4	2	6	20	34
Case 31.—	2/25/21	E. P.	6	M	2	3	5	3	4	24	29
Case 32.—	3/18/21	G. B.	7	M	2	4	4	2	6	29	34
Case 33.—	3/21/21	W. I.	7	M	4	2	6	3	5	15	20
Case 34.—	3/23/21	J. M.	6	M	2	4	7	4	5	....	....
Case 35.—	4/ 4/21	D. C.	7	M	4	2	4	3	7	40	43
Case 36.—	4/14/21	C. P.	rt. 7	M	14	4	3	2	....	9	10
Case 37.—	4/14/21	C. P.	left	....	....	4	4	3	....	10	11
Case 38.—	4/15/21	E. H.	2	M	7	2	11	6	13	25	27
Case 39.—	4/21/21	J. K.	76	F	0	5	3	2	7	18	20
Case 40.—	4/28/21	M. P.	7	F	2	4	5	3	5	20	22
Case 41.—	4/30/21	F. K.	23	F	3	4	8	3	10	22	28
Case 42.—	5/11/21	E. K.	7	F	2	5	7	2	6	15	20
Case 43.—	5/25/21	L. M.	7	F	1	5	6	3	4	23	21
Case 44.—	6/ 6/21	C. B.	8	F	1	4	4	1	3	10	13
Case 45.—	6/16/21	W. O.	7	M	7	6	2	1	10	11	12

COMPLICATIONS.

Case 1.—Fatal case of old C. C. O. M., converted into radical operation. In spite of skin sloughing, wound clean on postmortem. Death fourteenth day; leptomeningitis not of otitic origin, pneumonia.

Case 5.—Erysipelas of face and scalp on third day.

Case 8.—Mother tuberculous.

Case 14.—Zygomatic extension 20 days postoperative curetted, healed.

Case 15.—Left observation 17 days postop. Reported small fistula four months postoperative. Father tuberculous.

Case 18.—Sequestrum removed three months postoperative. Mother since died of tuberculosis.

Case 21.—Mastoid complicating scarlet fever.

Case 22.—Slight postoperative cellulitis of the neck.

Cases 27 and 28.—Zygomatic extension right side, healed by curettement 30 days postop. Recurrence where someone had done partial mastoid three years before.

Case 32.—Mastoid complicating measles.

Case 33.—Recurrence where someone had done partial mastoid four years before.

Case 34.—Postoperative treatment elsewhere; healing delayed 30 days by forgotten stitch.

Case 35.—Bronchopneumonia 20 days postoperative.

Cases 36 and 37.—Death 14 days postoperative from coexistent purulent meningitis. Mastoids clean on postmortem. Focal abscesses both tonsils.

Case 38.—Some sloughing of skin.

Case 39.—Mastoid ten days after acute bronchopneumonia.

Case 45.—Acute nephritis, mastoid and pneumonia due to tonsillar abscesses found at operation.

Mastoids 1, 14, 15, 18, 27, 34, 35, 36 and 37—nine in all—are excluded from totals regarding this technic, because of general or local complications as noted.

XVI.

ACUTE LACUNAR ADENOIDITIS.

By Samuel Salinger, M. D.,

Chicago.

Acute lacunar adenoiditis is pathologically similar to acute follicular tonsillitis with which it is frequently associated.

Because of this association and the fact that the tonsillar affection is more widely known and more readily diagnosed, the adenoiditis may frequently be overlooked entirely and run its course undiagnosed and untreated, with the possibility of recurrences and sequelæ.

Ordinarily, having diagnosed the tonsillitis, one is not likely to examine the nasopharynx. In fact, with tonsils and pillars acutely inflamed and swollen, it is not an easy matter to do a posterior rhinoscopy on account of the narrowing of the fauces and their heightened irritability. The presence of numerous yellow or white capped enlarged lymphatic follicles on the posterior wall of the oropharynx as well as along the nasopharyngeal fold should always excite suspicion of the process higher up and lead one to pursue the examination further.

Less frequently the adenoids may become acutely inflamed without involving the tonsils at all, or the process may occur in patients whose tonsils are out. These cases should present no difficulties in diagnosis, despite the apparently normal appearing fauces and oropharynx. All that is necessary is that one take the trouble to use the mirror or else examine the nasopharynx by anterior rhinoscopy, as will be described later.

Two cases in point will be briefly cited:

Miss K. T., aged 23 years, had her tonsils removed in June, 1917. For some time after, she complained of aching in the ears and received treatment, but with no permanent relief. A few days before appearing in our clinic she had a chill and a rise in temperature with severe pain in both ears and in the throat. The examination disclosed the following: Both membrana tympani were normal except for a slight retraction and a bit more translucency than normal. Nothing was found in the

nose but a moderate swelling of the turbinates. After the application of adrenalin, the posterior nares could be made out and were seen to be full of a thick mucopurulent secretion.

The tonsils were absent, but the pillars were intact and not the least inflamed. The oropharynx was also normal. On inspection with the mirror the nasopharynx was found to be filled with a large mass of adenoids, which were markedly inflamed and covered with a thick, tenacious mucopurulent secretion. A partial cleansing revealed the depressions in the adenoid mass oozing the same type of secretion. Cultures later showed the predominant organism to be the streptococcus. The posterior cervical glands on both sides were enlarged and tender.

The temperature during the attack varied from 100 to 102.6 degrees F.

Under local cleansing treatment plus applications of argyrol, the condition cleared up and, despite our insistence, the patient elected not to have the mass removed, although it was easily the size of a hickory nut.

Case 2.—Miss N. R., aged. 18 years, came in as a suspected acute mastoid. She gave a history of severe pain in the region of the tips of both mastoids radiating into the neck, elevation of temperature, general malaise and muscular soreness, and pain in moving the mandible. There was tenderness and enlargement of the posterior cervical glands on both sides. The external auditory canals and drum membranes were found to be absolutely normal. The tonsils were slightly enlarged and moderately reddened. The adenoids, on inspection with the mirror, were found to be large and lobulated and covered with an exudate which could be seen extending deeply into the recesses of the mass. This case also recovered within a few days.

The symptoms as described in these cases are substantially as found in various textbooks. There seems, however, to be some slight differences in the nomenclature of the disease.

Gottstein and Kaiser[1] describe it as acute follicular or lacunar adenoiditis and draw a distinction between it and simple catarrhal inflammation of the adenoid. They further mention a more severe type as "acute phlegmonous inflammation of the adenoid," in which there is an abscess formation that may

rupture spontaneously or may burrow downward, presenting in the oropharynx as a retropharyngeal abscess.

Zarniko[2] considers three types of acute inflammation of the adenoids, the catarrhal, lacunar and follicular, although the distinction between the two latter is not made very clear. He mentions acute rhinitis, otitis media, epipharyngeal abscess and metastic infections as complications likely to ensue.

Kyle[3] describes it only as "acute nasopharyngitis," considering the inflammation as of all the tissues of the nasopharynx rather than the adenoids alone.

Grünwald[4] in his Atlas gives a very good picture of the disease, which he calls "acute lacunar inflammation of the pharyngeal tonsils."

Ballenger[5] presents a clear description of the disease and calls attention to reddening of the lateral pharyngeal folds, which are frequently studded with yellowish spots, indicating infection of the numerous lymphatic follicles in the oropharynx.

The etiologic factors as a rule are exposure to inclement weather, a general state of depressed vitality and infection with streptococcus.

Bryant[6] reports ten cases of streptococcic infection of the adenoids which were all cured by local treatment.

A consideration of the cases cited above brings forcibly to mind not alone the necessity of thoroughly examining the nasopharynx in every instance where earache is a symptom, but also the important fact that many adults possess large masses of adenoid tissue which have failed to undergo the regressive changes generally assumed to have taken place with puberty. It is surprising, if one will take the trouble to look, how many adults harbor appreciable masses of these vegetations. Practically no age is exempt.

Logan[7] reports that out of a series of 652 adenoidectomies 284, or about 40 per cent, were on patients between the ages of 25 and 59. He further cites another case in a patient of 64 years.

Cuvillier[8] saw two cases at the ages of 60 and 65 years. Solis Cohen[9] had one in a man of 70 years. Schaeffer[10] reports one at the age of 71 years, and Couetoux[11] another at 72 years.

Lewis[12] further quotes several more recent observers along the same lines.

It is important that this knowledge be given wide circulation, not so much on account of the acute attacks of adenoiditis (which are usually self limited and of no great severity), but because of their recurrence and the numerous more serious consequences which may follow in their wake. Current medical literature is full of references to the adenoids as the cause of nasal obstruction, middle ear affections, chronic laryngitis, and so far as laryngologists are concerned the subject is a closed book.

The general practitioner, however, I find, is somewhat lacking in knowledge of these facts, particularly with reference to adult patients. The principal reasons for this are the usual acceptance as dogmatic of the dictum that adenoids disappear with maturity, and the lack of skill in making examinations of the nasopharynx.

Physicians as a rule make their diagnosis of adenoids by palpating with the index finger in the nasopharynx, which, to my notion, is an unnecessarily painful and disagreeable procedure. It has been my custom, in teaching students, to demonstrate to them that when by reason of lack of practice on the part of the examiner or an unruly pharynx the posterior rhinoscopy cannot be successfully performed, the adenoids can clearly be made out by anterior rhinoscopy if the inferior turbinates have previously been well shrunk with adrenalin. Unless the turbinates are excessively hyperplastic or a very markedly thickened, deviated septum is present, the procedure can always be carried out. All that is necessary is that adrenalin be liberally applied the whole length of the turbinate and that the light be properly focused. By holding the patient's head bent a little forward of the erect position and directing the light along the floor of the nose or between the turbinal and the septum, and by coming a little closer to the patient than for the ordinary anterior rhinoscopy (bearing in mind that the focal distance of the mirror is a fixed point), the examiner is enabled to illuminate the posterior nares and roof of the nasopharynx. Of course, with the Kirstern light the problem of focusing is simplified. If the adenoids are very large and irregular, they can at once be made out by their very irregu-

larity of contour, their pendulous position and the numerous lights and shadows produced by the examining light playing over the surface. If the mass be smooth, as frequently it is in adults, it can be outlined by having the patient say "k" or "cocoa," which brings the soft palate upward against the mass and alters its position. It will be noted at the same time that the reflected light moves with the mass. Where the adenoids are very large they may be seen to reach down to the level of the inferior border of the lower turbinal, and adenoids of any appreciable size nearly always stop the soft palate from reaching its proper height during contraction, as compared with normal.

This method, while difficult at first, can nevertheless be perfected with practice, and is particularly recommended for examining children, as well as adults.

A painful and disagreeable procedure, such as palpation of the nasopharynx, should be avoided because it leaves a horrible impression on the minds of the little ones which will alienate them from physicians in general and make future examinations difficult.

To conclude:

1. Adenoids in appreciable masses are of frequent occurrence in adults.

2. Acute lacunar adenoiditis should be thought of in cases of earache with fever where the ears are normal, regardless of whether the tonsils are absent or present, inflamed or not.

3. Diagnosis of adenoids should always be attempted by anterior rhinoscopy in preference to palpation in cases where posterior rhinoscopy cannot be carried out.

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XVII.

THE PROBLEM OF THE HARD OF HEARING AND ELECTRICAL HEARING DEVICES.*

By George E. Shambaugh, M. D.,

Chicago.

Otologists have been interested principally in the diagnosis and treatment of diseases affecting the organ of hearing. There is another problem of great importance that is the legitimate function of the otologist to help solve, and that is the problem of what can be done for those cases of increasing deafness which are not amenable to treatment. Otologists as a class have been slow to appreciate their obligation in these cases. The result is that those afflicted in this way have been left largely to their own resources in attempts to solve their problems. It is important that otologists take up more seriously the question of what can be done for these cases. The field is rather an extensive one, for it involves social and economic questions as well as the important one of what can be done to bridge over the chasm resulting from the defect in hearing. The busy otologist, with his interests centered on the diagnosis and treatment of diseases of the ear, finds himself handicapped by the lack of time necessary to carry the extra burden of solving these additional problems. Fortunately, there has grown up an institution, the comprehensive aims of which are to ameliorate the condition of those who are losing their hearing. This institution is the League for the Hard of Hearing, which aims not only to assist in bridging over the chasm created by the loss of hearing, but as well in solving the social and economic problems of these cases. Already there exists in several of our larger cities similar leagues to that which Dr. Phillips has been instrumental in organizing in New York. It becomes the duty of otologists to assist in every way possible in the organization of similar leagues throughout the coun-

*Read before the joint meeting of the Chicago Medical and Chicago Laryngological and Otological Societies, Nov. 9, 1921.

try to take up the work at the point where the efforts of the practicing otologists cease.

Our work as otologists will continue to be chiefly in the diagnosis of ear disease and in the treatment of those cases where treatment is of assistance, but we should not neglect the important duty of giving proper advice to those cases where the condition does not call for local treatment. First of all, it is our duty to give advice regarding the value of taking up lip reading and to assist these patients in selecting proper devices which serve as aids to the hearing. It is in regard to the latter that I desire to make a few observations. A large number of such devices exist, some of which are of use in one type of deafness, some in others. Still others have no particular value, and some devices advertised as aids may even be a source of danger to the remnant of hearing. It is clearly the business of the otologist to be able to advise his cases intelligently regarding the use of these instruments, yet, as I have already pointed out, we have been negligent in not taking seriously enough this responsibility. We are all aware how hopeless it is for the patient unadvised to find out these facts for himself. Some of these devices, especially the "artificial ear drums," as well as certain electric hearing devices, are advertised to the public, making extravagant claims that are, to say the least, misleading. What are the facts regarding the value of these devices intended as aids to the hearing? I shall not attempt to discuss in detail all there is to learn about these instruments, but shall point out some of the outstanding facts about which as otologists we should be informed.

In the first place, it is hardly necessary to say anything much about the abused use of "artificial ear drums." Such devices are of especial assistance only in exceptional cases of chronic suppurative otitis media with destruction of the conducting mechanism in the tympanum, and then only, of course, where the defect in hearing is quite marked and involves both ears. The simple rubber disc with a string attached to assist in carrying it into the fundus of the canal, and by which it may be withdrawn, is all there is to this device. Usually the patient himself learns to adjust this so that it is lodged properly against the remnant of the stapes so as to improve the

response of this important link of the sound conducting mechanism to sound impulses.

It is more especially in regard to the hearing devices intended for the nonsuppurative ear diseases to which I desire to call attention. There are in general two types of instruments intended for these cases. One type consists of a device intended to assist in collecting sound waves from the air and conducting them into the external meatus. These are the ear trumpets and speaking tubes. The other type operates on the principle of the telephone receiver with a pocket battery. These two types of instruments are not equally useful in all forms of deafness. In a general way, it may be stated that the ear trumpet and the speaking tube are of assistance in cases of obstructive middle ear deafness, as well as in those of primary nerve deafness. It is in the latter, however, where they find their greatest application. In the more advanced cases of nerve deafness the speaking tube is the only hearing device that affords any material assistance.

A great deal of confusion exists among otologists regarding the application of the electric hearing devices, of which there are a number on the market. A canvass of some of our leading otologists has brought out the fact that a few do not recommend these devices for any of their patients, while admitting that some of their patients get them and apparently find them of assistance, since they continue to use them. Most of the men consulted recognized no particular type of deafness where such devices are of special value. A few expressed the belief that there exists some difference in the type of case benefited by their use without, however, being very specific as regards just what type received more assistance. As a matter of fact, there are some very definite facts regarding the application of these electric hearing devices. The first outstanding fact is that they are of distinct help only in certain types of deafness and not in others. In this respect they differ from the application of ear trumpets and speaking tubes, which, as I have already stated, are of assistance in all types of deafness. In a conversation recently with a man who is himself hard of hearing and who makes and sells an electric hearing device, I asked whether he recognized any difference among

the hard of hearing in the usefulness of his apparatus. His reply was so much to the point that I shall give in substance what he had to say. In the first place, he was very emphatic that a difference does exist. Some cases were very much benefited by using his device, while with others he found it of no special assistance. What was to me more interesting was that he was able to select the cases where it is was applicable before making any tests. For example, he had observed that a person who developed deafness after the age of 50 was not benefited unless the defect had its onset much earlier in life, and it had become very severe only later. In the second place, he asserted as a general principle that it was only in cases where the hearing was noticed to be better when the patient was riding on the cars that were benefited. We have in these statements what is apparent to all otologists, a rough differentiation of two types of deafness. On the one hand are the cases of pure nerve deafness, those where the trouble had its beginning after the age of 50, and on the other hand the cases of obstructive middle ear deafness, including especially the cases of bony fixation of the stapes.

In this connection it may not be amiss to point out the fact that a defect in hearing is always due to one of two conditions, either of which may be acting separately in particular cases, or both may be active in the same case. In the first place, there is the defect in hearing caused by some obstruction to the sound impulses reaching the nerve of hearing. The simplest example of this type of trouble is where the canal of the ear is occluded by a plug of cerumen. Anything which causes fixation of the sound conducting mechanism in the middle ear produces a defect in hearing by hindering the transmission of sound impulses from the outer air to the end organ of hearing in the cochlea. This includes the several types of middle ear disease as well as the condition known as primary fixation of the stapes. It is the latter process which is the principal cause of the hearing defect in most cases of hereditary deafness.

The second cause for defective hearing is where the nerve of hearing fails to respond normally to the impulse of sound waves. This is called nerve deafness. This condition may develop primarily, but it frequently develops secondary to long standing obstructive middle ear deafness.

The otologist finds no difficulty in differentiating these two types of deafness, especially where they develop independently of each other. Confusion is sometimes caused by the mixed types of deafness—that is, where there is an interference with the sound impulses reaching the nerve, as well as a defect in the nerve itself. More difficulty is experienced in distinguishing the several types of obstruction in the sound conducting mechanism.

I have rarely seen a case of pure nerve deafness which received any considerable assistance from the use of an electric hearing device. Cases of deafness coming on after the age of 50 are with very few exceptions cases of primary nerve deafness. Of course, not all cases of primary nerve deafness have their origin late in life. A few of these patients begin to lose their hearing in middle life at the time when bony fixation of the stapes usually begins to appear, or even in childhood. The diagnosis of such cases presents no particular difficulty to the otologist.

It is in the cases of obstructive middle ear deafness where the electric hearing devices are of benefit, and it is particularly in those cases where the obstruction is due to primary fixation of the stapes that they are especially useful, because it is in these cases as a rule where the defect becomes so severe as to render the use of a hearing device of practical value. Increased bone conduction seems to be essential, and in most of these cases the symptom of paracusis Willisi (the ability to hear better in a noisy place) is present. It does not matter that in these cases of long standing obstructive deafness degeneration in the cochlea sooner or later develops, as is particularly conspicuous in otosclerosis. The associated nerve deafness is no contraindication to the application of the electrical device, because there continues to be an increase in the bone conduction resulting from the fixation of the stapes, so long as there is any function left in the cochlea. It is easy to understand why even in these advanced cases of otosclerosis such devices continue to be of assistance. The cochlear defect begins by destroying the upper part of the tone scale, which is of little use in the perception of hearing for the voice. The lower part of the scale is preserved until the very end, and this is the part of the scale used in conversation. The in-

creased bone conduction for the lower part of the tone scale continues, and therefore the usefulness of the electric hearing device continues, even in the presence of an extensive nerve degeneration. I can see nothing but harmful results possible from the use of a noise making apparatus which is often urged upon the patient as a means of developing his hearing powers.

XVIII.

THE BACTERIOLOGY AND HISTOPATHOLOGY OF THE ADENOIDS.*

FROM THE DEPARTMENT OF PATHOLOGY AND BACTERIOLOGY OF THE UNIVERSITY OF ILLINOIS, COLLEGE OF MEDICINE, CHICAGO.

By Isadore Pilot, M. D.,

Chicago.

Adenoids have been discussed for many years with reference to their hypertrophy and resulting obstructive symptoms and to their rôle as a portal of entry in tuberculosis. One phase entirely neglected has been the bacteriology. The following data represent the first systematic bacteriologic studies of the selected parts of the nasopharynx, the vegetations or adenoids. While many investigations of the bacterial flora of the nasopharynx with special reference to the carrier problem have been made, such work has always been carried out with cultures obtained with a swab which can at best touch the surface of the vegetations. These studies cannot be accurate in determining the extent the adenoids may harbor bacteria for like in the tonsils the flora of the crypts is different from that of the surface. To obtain more accurate knowledge of the incidence and numbers of the more common microorganisms and to ascertain the extent these organisms flourish in the recesses of the nasopharynx, a study was undertaken of the extirpated adenoids. Histologic studies were made to bring out the cellular changes, if any, to the presence of the bacteria and to correlate any particular pathologic condition with the character of the bacterial flora.

The material was obtained from children in the laryngologic ward of the Cook County Hospital during the months from April to November, 1920. The patients, ranging from five to fifteen years of age, were afebrile, with no acute inflamma-

*Read before the Chicago Laryngological and Otological Society, October 3, 1921.

tory condition of the respiratory tract, and presented tonsils and adenoids with varying degrees of hypertrophy. The adenoids were removed under general anesthesia, in most instances with the La Force adenotome.

The vegetations when well removed consisted of a soft mass of lymphoid tissue, varying in size from ½ cm. to 1½ cm. in all diameters. Practically all presented folds of tissue leaving one to five or more clefts of varying depth. In many specimens the folds had become partially united, leaving pits or slits from a few millimeters to a centimeter in length and depth. These pits resembled the tonsillar crypts, but as a rule were not as deep and did not tend to be narrower at the orifice than at the base. Most of the adenoids presented both folds and such cryptlike depressions. Many revealed only the folds, while a few were entirely pitted with the crypts. Gross evidences of pus were not encountered, but occasionally the crypts were filled with soft yellow fatty debris which microscopically consisted of amorphous material, cholesterol crystals and a few epithelial cells, leucocytes anad bacteria. Direct smears from the surface and depths of the vegetations revealed varying numbers of cocci and bacilli and cellular debris. The cocci appeared in short chains, often in pairs, spherical like staphylococci and streptococci, frequently lancet shaped like pneumococci. The bacilli were of different types, some like diphtheroids and others small pleomorphic, like influenza bacilli. Spirilla were observed in a few instances. The cells were chiefly desquamated epithelium, both of the squamous and cylindrical type, and leucocytes of the small and large mononuclear type, and a few of the polymorphonuclear variety.

The adenoids were collected in sterile gauze and cultures made from them in one to four hours. Macerated specimens were discarded. With a wire loop the surface of the vegetations was scraped and inoculated upon media, and then another culture was made with material obtained with the loop from the depths between the folds and the cryptlike depressions. The adenoids of 103 children were thus cultivated upon unheated blood agar and heated blood agar for the influenza bacillus. The adenoids of 100 other children were similarly

studied upon Loeffler's serum medium for the diphtheria bacillus.

Every adenoid gave positive growth. The cultures from each adenoid showed several organisms, regardless of the size or structure of the vegetation, occasionally one organism predominating, rarely, however, in pure culture. The incidence of the various bacteria found are indicated in Table 1.

Hemolytic streptococci (1) occurred in 61 per cent of the cultures of the depths of the adenoids and in 58 per cent of the cultures from the surface. In 18 instances these organisms were quite numerous, and in three were found in practically pure culture. It is noteworthy that in the specimens with crypts these streptococci were usually more numerous than in the vegetations without such structures. In their behavior toward carbohydrates and in their pathogenicity for rabbits and mice they correspond with few exceptions to the streptococcus pyogenes group. Streptococci of the viridans type (2) were encountered in 89 per cent. On the basis of carbohydrate fermentation 30 per cent of the strains were of the streptococcus mitis group, 64 per cent of the streptococcus salivarious, 6 per cent of the streptococcus fecalis. Streptococcus mucosus was noted in 3 per cent. Large moist green colonies corresponding to the socalled Mathers coccus of the recent influenza epidemic occurred in 17 per cent. Pneumococci were found in 65 per cent, in four instances in practically pure culture. Classified according to agglutination with specific type 1, 2 and 3 serums, 85 per cent of the strains were 4, 13 per cent type, 3, 2 per cent type 2. Influenza bacilli (3) were identified and isolated from the chocolate medium in 40.9 per cent, frequently in large numbers. They were hemoglobinophilic, pleomorphic and showed the distinctive property of symbiosis. Diphtheria bacilla (4) were recovered in 12 per cent from Loeffler's medium, often in large numbers, and in two instances in pure culture on this medium. Two strains were toxin producing, while the remainder were relatively avirulent. Diphtheroids occurred in 30 per cent and were differentiated by their morphology and inability to ferment the common sugars. The staphylococci appeared in 60 per cent, chiefly as the albus type. Gram neg-

ative cocci, consisting chiefly of the micrococcus catarrhalis, micrococus pharyngis siccus and a few like meningococcus, were present altogether in 79 per cent. The Friedlander bacillus was found in 14 per cent and the B. fusiformis in 20 per cent of the ten anerobic cultures.

The flora of the nasopharynx, as revealed by cultures obtained with the swab, was compared to the flora of the surface and depths of the adenoids. The hemolytic streptococcus was found in 40 per cent of 25 persons in the cultures from the swabs, while the excised adenoids yielded larger numbers in 60 per cent of the same individuals. The greatest incidence and numbers of bacteria occurred in the depths between the folds and in the crypts of the vegetations, lesser numbers on the surface epithelium and least upon the swabs of the adenoids in situ.

The excised faucial tonsils of the same individuals were similarly compared and found to be somewhat different in their flora. Hemolytic streptococci occurred in 95 per cent of 21 pairs of tonsils, often in large numbers, as compared with fewer numbers in 71 per cent of the adenoids. Influenza bacilli were found in 53.9 per cent of 115 pairs of tonsils, whereas they were encountered in 40.9 per cent in the vegetations. Both adenoids and tonsils yielded the same percentage of diphtheria bacillus (12 per cent), but in considerably larger numbers in the latter. The diphtheroids, on the other hand, were present in only 17 per cent of tonsils, while the adenoids gave positive results in 30 per cent. From these results it can be stated that the tonsils harbor greater numbers of hemolytic streptococci, influenza bacilli and diphtheria bacilli, while the adenoids favored the lodgment of the Gram negative cocci and the diphtheroids.

The flora of the nasopharynx was further investigated in children whose adenoids and tonsils had been removed and compared with a similar group in which the adenoids and tonsils were present. Hemolytic streptococci were found in 11 of 27 individuals without tonsils (40.8 per cent), as compared with 27 of 48 with tonsils (56.3 per cent); influenza bacilli in 8 of 29 tonsillectomized (26.5 per cent), and in 17

of 43 nontonsillectomized (39.3 per cent). Pneumococci were found in about the same percentage (32.5 per cent) in both groups. The numbers of all of these organisms were decidedly fewer in the tonsillectomized children. It would seem therefore that the removal of tonsils and adenoids diminishes the incidence of dangerous bacteria, but by no means causes their disappearance. The remaining pitted follicles of the oro- and nasopharynx undoubtedly continue to harbor these organisms.

Histologic sections were made of the adenoids from 75 individuals, all of which had been studied bacteriologically with a view of determining if any distinctive cellular reaction resulted as a response to the presence of any particular bacterial flora. The first striking feature is the hyperplasia of the lymphoid tissue, with no other very remarkable changes. The degree of hyperplasia varied in different adenoids. The condition appeared as large follicles with active germinal centers showing many mitotic figures. The small lymphocyte was very predominant, with an occasional endothelial and a few polymorphonuclear leucocytes in their midst. In a few instances the endothelial cells seemed to have proliferated, forming small islands of large cells. The follicles made up the greatest part of the vegetation, except in the smaller adenoids, where the diffuse lymphoid tissue equaled or exceeded the area covered by the follicles.

The folds and cryptlike depressions were lined with epithelium under which lie the lymphoid follicles. The epithelium was chiefly of the stratified columnar ciliated epithelium variety, merging occasionally into the stratified squamous near the ends of the vegetations. The columnar epithelium frequently showed a tendency to become modified, particularly in the deeper portions of the clefts and cypts, into two or three, or even a single layer of columnar cells, especially in specimens with very large follicles located immediately underneath. At times it was difficult to see any epithelium; the lymphoid tissue apparently lies exposed with no cellular evidences, however, of any ulcerative process. Throughout just underneath the epithelium polymorphonuclear leucocytes and plasma cells could be seen in varying numbers. Between the folds and in

the depths of the crypts debris consisting of disintegrated epithelial cells with an occasional polymorphonuclear leucocyte and lymphocyte, was often encountered. A few specimens revealed hyaline, pink staining material containing a few cells and bacteria, which material when examined in the fresh specimen was made up of amorphous fatty masses and cholesterol crystals. The epithelium about such masses was usually thin and often squamous in character. In sections stains by the Gram-Weigert methods bacteria were surprisingly few. An occasional diplococcus or bacillus was found on careful search on the epithelial surface or free in the cellular debris, but was not detected in the depths of the lymphoid tissue.

Connective tissue was variable in amount, appearing in larger amount in the vegetation showing considerable diffuse lymphoid tissue. Plasma cells and eosinophiles were often seen in the connective tissue, especially about the blood vessels. At the base of the vegetations mucous glands frequently occurred.

No striking pathologic changes could be ascribed to any flora or organism. The adenoids with deeper folds and many crypts, particularly those containing amorphous and cellular debris, as a rule harbored larger numbers of bacteria, especially hemolytic streptococci. For the most part histologically the specimens were uniform in their appearance, regardless of the character of the flora. Every adenoid presented evidences of chronic inflammatory change no greater in degree than the changes that are present in the lymphoid tissues in close proximity to the mucous membranes of the normal individual. In none were found acute cellular reactions to the presence of the organisms that lie in close contact with the vegetations.

In the great majority of individuals bacteria apparently lie dormant as saprophytes in the adenoids without exciting acute local or general symptoms. These organisms may stimulate gradually hyperplasia with plasma cell and slight leucocytic infiltration. Like in the tonsil, a variety of dangerous bacteria exist without harm to the individual as long as the resistance of the local tissues and of the body is good. In the

course of acute infections involving the respiratory passages, as in the exanthemata, influenza and other diseases, the local resistance of the tissues becomes lowered in some unknown way by the primary virus or parasitis bacterium, and the general resistance is diminished by the acute toxemia. Under these conditions the saprophytic organisms no longer lie dormant but become invaders growing rapidly in neighboring tissues, into the blood and lymph stream, with the resultant serious complications. In this way the streptococcus, influenza bacillus and other bacteria give rise to the secondary infections of the lungs, heart, the middle ear, the accessory sinuses, meninges and other parts of the body.

From these studies it is well to recognize that the nasopharyngeal vegetations should be regarded not only as hyperplastic obstructive masses but also as foci like the tonsils, where dangerous bacteria are lodged. This conception is to be borne in mind in connection with the treatment of diphtheria carriers where the removal of the adenoids as well as the tonsils frequently terminates the carrier state. In the treatment of the metastatic infections, such as endocarditis and arthritis, the adenoids should be regarded as possible foci of infection. Although probably not as important in this respect as the faucial tonsils, the adenoids are to be looked upon as a portal of entry of many acute and chronic diseases.

THE INCIDENCE OF COMMON PATHOGENIC BACTERIA IN THE ADENOIDS.

Organism	Number of Individuals	Per cent Positive
Streptococcus hemolyticus	103	61
Streptococcus viridans	103	89
Pneumococcus	103	65
Type 2	103	2
Type 3	103	10.3
Type 4	103	52.7
Mathers coccus	103	17
Staphylococcus	103	60
Gram negative cocci	103	79
B. influenzæ (Pfeiffer)	115	40.9
B. diphtheriæ	100	12
Diphtheroids	100	30
B. mucosus capsulatus	103	14
B. fusiformis	10	20

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SOCIETY PROCEEDINGS.

THE CHICAGO LARYNGOLOGICAL AND OTOLOGICAL SOCIETY.

Annual Meeting, May 2, 1921.

THE PRESIDENT, DR. ALFRED LEWY, IN THE CHAIR.

Symposium: The Future of Otolaryngology in Chicago."

DR. ALFRED LEWY said that with the idea in mind that this was a forward looking society, one of the members of the council, who was a good friend of his and of the society, suggested this program in lieu of the customary retrospective presidential address usually given at the annual meeting. Among our members are quite a number of men of wide reputation as investigators, teachers and clinicians, several of whom had consented to lead the discussion, each taking up briefly some particular phase of the subject. The first to speak would be Dr. J. Gordon Wilson, his subject being "The Training of Students Toward Greater Accuracy."

DR. J. GORDON WILSON believed the future of laryngology in Chicago depended on the ideals of those practicing the specialty, on the standards of proficiency they endeavored to maintain. This society, composed of the leading specialists in otolaryngology, ought to play an important part in determining this future. Various views would no doubt be presented, for the pathways of progress are many. There was, for example, a recommendation of the council in regard to research in otolaryngology. Such required ample time and necessitated some sacrifice. It required laboratory facilities and presumed the acquirement of preliminary knowledge and technic. Few have the opportunity or training to explore unknown fields, but one field necessary to the advancement of this specialty was open to all—namely, careful observation of cases and accurate records. Everyone acknowledged the importance of accurate observation and, in reports, the need of careful statements of facts in simple language, but such are too often wanting. Accurate observations of conditions was not easily acquired. Symptoms as given by the patient were often inaccurately noted. Those who have frequently to look

up case reports know the inadequacy of many of these. This was a profitable field in which each could assist. This society should insist, so far as it can, that papers presented and afterwards published be devoid of errors in observation and statement.

Dr. Wilson pointed out the fact that they were sadly deficient in postmortem reports in otology. Surely in this society they ought to be able to show some work on the microscopic examination of ear cases carefully tested during life.

DR. GEORGE E. SHAMBAUGH stated that there are two phases of work in connection with graduate instruction in otolaryngology which have usually been confused. One is the work which a man should do preparatory to taking up the specialty. The other has to do with providing short review courses for those already established in the specialty. These are often called "brush up" courses. These men do not care to spend a long period of time on such work, but wish to have in a short time an opportunity to add to their knowledge regarding some particular subject. The phase of work of preparing for special practice is quite a different proposition. These men need prolonged, careful study, lasting at least a year. Very little effort has been made to provide this sort of training in this country. The men entering our special field have been forced to rely upon the short, intensive, "brush up" courses which are suitable especially as review courses for those already established in the specialty. This is the same sort of work that they have found when they went abroad. Very few found the opportunity of doing the fundamental work by filling the place of clinical assistant for a long period in some properly equipped and properly organized outpatient department. The sort of preparation that these men have received has been, to say the least, very unsatisfactory. Proper preparation cannot be obtained by listening to lectures and clinics and by filling a notebook full of medical facts. When the medical student has finished his undergraduate course he should be through, in a large measure, with "spoon fed" instruction. His development from that time on depends largely upon his own initiative, and the most substantial assistance we can give him is to provide proper facilities and opportunities for doing the right kind of work, but it should be

up to him to work out his own salvation under such conditions.

Dr. Shamhaugh called attention to the fact often overlooked by our men seeking preparation in the special field, that the foreigners have never relied upon the taking of courses. These courses were provided to satisfy the demands of the American students, who somehow have been imbued with the idea that by paying out money to an instructor for ladeling out facts for his consumption, he will get that which he is too indolent to work out for himself. The American Medical Association in its Council on Medical Education has taken up seriously this question of providing a proper minimum standard of preparation for those desiring to enter the special fields of practice. The Committee on Otolaryngology insists on the principle that the preparation for special practice should be put on the basis of genuine graduate instruction, in which facilities are provided for doing the work, but the student must work in a large measure independently under supervision but not by course taking. The plan approved of consists of one and one-half years' full time work. For the first year this work must be done at one place. One-half of each day to be devoted to the clinical study of cases in a properly equipped and properly organized outpatient department, such as exists in connection with many of our Class A medical schools. In this work the student is required to learn how to examine cases and how to make proper diagnoses. It is only in the latter period of the course that instruction in operating is provided. The other half day is to be spent in the laboratory of the university working on the fundamental sciences, especially the anatomy of the ear and nasal cavities. Here the same type of work is insisted upon: The student must work out the subject himself under supervision but not by course taking. After this year of fundamental training it is suggested that as far as the opportunities permit these men shall secure positions as interns in special hospitals or as residents in otolaryngology in general hospitals where they shall spend the minimum of one year. Those who are unable to secure such opportunities should spend the last six months necessary to fill out the minimum eighteen months' requirement by continuing the work of the first year, or by taking such courses in various medical centers as would meet the approval of the

institution where they have taken their first year's work, or by working as assistants in the office of some established specialist. On the completion of this work it is suggested that the institution where the first year's work has been taken should issue a certificate stating that the student has had proper preparation for undertaking special practice.

As for providing facilities for this work, these already exist in connection with many of our Class A medical schools. It has been generally accepted that 100 men turned out each year would amply fill all the legitimate requirements to take care of all the ear, nose and throat work in this country. For some years the country has been swamped with general practitioners, many of them rather unsuccessful, who have come to clinics and learned something about two or three operations of the nose and throat, and on the strength of this have gone back as specialists. Dr. Shambaugh thought one could easily say that if all of these men had proper training in the examination and diagnosis of cases so that they could appreciate the proper indications for surgical interference, only a small percentage of the operations which they are now attempting to do would be recommended.

The Facilities for Postgraduate Work in Chicago.

DR. OTTO J. STEIN said this was a difficult subject for him to speak upon because they had as yet not formulated any definite plan upon which to carry out their own work. Many critics have attacked postgraduate teaching with the idea that such schools tend to create specialists, but this he wished to emphatically deny. He believed this idea had arisen from the fact that many men attend the postgraduate schools and then return home and practice some one specialty, but he believed that this did not mitigate against the idea that these schools make specialists. They do not give men certificates saying that they are specialists, but give them a statement of attendance saying that they were in the school for a certain length of time taking courses in that particular line.

Medicine has changed from the homogeneous science of older days to a more complex science, split up in heterogeneous groups, and otolaryngology has become a separate science, but this has not yet been recognized by the medical

schools, and they still insist on teaching undergraduates otolaryngology. This often gives students an idea that they know something about this specialty, they attend a postgraduate institution after gradauting, and if they like this specialty they study it and go back and practice it. Dr. Stein thought that medical science is now large enough for a student to devote all his time to the fundamental branches without going into any of the special branches, and was inclined to criticise any schools that give undergraduates instruction in otolaryngology. The surgeon could, of course, speak of the complications of the nose and throat as he sees them and could touch upon the anatomy, and the man in general medicine could touch upon the complications as he sees them, but no special instruction in any specialty should be given to undergraduates. He believed that steps were now being taken to have this matter remedied.

Dr. Stein believed the otolaryngologist himself is much to blame for the attitude of the general public in reference to this specialty. The specialty is too much split up, one man not doing any work on the larynx, another not doing bronchoscopy, another not doing mastoid operations. He believed that if a man wanted to be a specialist he should be thoroughly trained and able to understand, treat, discuss and teach all phases and branches of the specialty.

Another point touched upon by Dr. Stein was that the general practitioner should not be blamed for working in this specialty, for he has been given the impression in his undergraduate days that he is receiving some training in this line. He often is better qualified to do the work than the men who are associated with one in the same hospital and community, who are recognized as great surgeons, or orthopedists, or pediatricians, but who dabble in this specialty without ever taking a special course in the work.

Dr. Stein believed the future of this work rests entirely on two phases of the subject: First, the work must be thoroughly standardized, as the outline given by Dr. Shambaugh showed to be possible. Second, each one in the specialty must be thoroughly equipped and able to take out tonsils, or remove a turbinate, or do mastoid operations or anything else that may be required, and not limit himself to any one or two

phases. Much depends upon the institutions by which we will create proper material from which these men will profit.

The Future of Defects of Speech in Chicago.

DR. ELMER L. KENYON stated that disorders of speech are as inevitable as disorders of the nose, or of the ear, or other anatomics—physiologic disorders of the body—and their treatment just as essential. The field is just as definitely a medical field as is the field of otolaryngology in general. One trouble is that this field of effort does not fit in with the conventional tendencies of specialization. Some disorders of speech are capable of being fully understood only by the otolaryngologist. Either the neuropsychologist should unite with the otolaryngologist and handle the subject jointly or else there should be special training in neuropsychology and otolaryngology for the especial purpose of handling this subject. During the reecnt war the Government placed responsibility for treatment of disorders of speech chiefly on the department of otolaryngology, and that helped to place responsibility for such disorders on this specialty.

A few years ago the Section on Otolaryngology of the American Medical Association created a permanent committee on the deaf child, and a year ago the section extended the work of that committee to include not only the deaf child, but the deaf adult, and also disorders of speech. It seemed to Dr. Kenyon that this was likely to prove to be an important step forward.

As to the present status of the work in the United States among physicians, so far as the speaker knew it, in Philadelphia, where Dr. Makuen worked so long and so well, no physician has taken up his work. Mrs. Steel goes on with Dr. Makuen's clinic in the Philadelphia Policlinic and takes care of disorders of speech so far as possible in the same way as when he was living. In New York, Dr. Scripture has gone to Europe and left Mrs. Scripture in charge of the speech work in the Vanderbilt Clinic. A few years ago, Dr. J. Sonnett Greene decided to go into the work of disorders of speech as an exclusive specialty. He started what is known as "The New York Clinic for Defects of Speech," and is occupying an old residence for the work. This clinic has had much publicity, has interested many of the influential people in New

York and has a large clinical patronage. It has no medical school connection. In Boston, for some years, Dr. Walter B. Swift has been doing speech work. His public work now consists chiefly in going to different parts of the country at different times, where he establishes for a period of about six weeks a center of instruction for lay teachers in the treatment of defects of speech. This is one of the means by which teachers in our schools in various parts of the country are now being instructed to a certain degree to take care of disorders of speech. In St. Louis, Dr. Max Goldstein has included disorders of speech in the work carried on by the Central Institute for the Deaf. At the University of Wisconsin, in Madison, Dr. Smiley Blanton is giving excellent instruction in this subject. In Chicago a clinic in defects of speech has been conducted by the speaker at Rush Medical College for about eighteen years. Instruction has long been given to the undergraduate medical students and is now beginning to be offered to graduate students of otolaryngology.

Dr. Kenyon thought that what was especially needed in Chicago was laryngologists who were willing to practice in this field. From the educational standpoint what was required were facilities or giving a certain minimum of instruction for the undergraduates in all medical schools, a certain larger minimum for the prospective specialists in otolaryngology and neurology, means for instruction to lay workers, and especially means for instruction to physicians who intend to specialize in disorders of speech. It seemed to him quite unlikely that all the medical schools in Chicago could ever have a clinic in disorders of speech. Instructors are certainly at present wholly inadequate, and clinical patients are likely to be diverted to the educational speech work in the public schools.

The way to handle the situaiton in Chicago, he believed, was to found an adequate institution which shall handle this field in a large way, from the treatment, research and the educational standpoints. This institution should furnish undergraduate instruction for all the medical schools in the city, for the graduate schools, for specialists in defects of speech and for lay workers. Such an ideal institution, Dr. Kenyon said, should be directed by the combined educational medical interests in Chicago. Only when such institutions have been

established here and elsewhere, and the question of knowledge and treatment have thus become standardized, will this field of practice begin to take its rightful place in service to mankind.

The committee of the Section on Otolaryngology of the American Medical Association hopes in another year to bring forward a program which will encourage the development of this field.

DR. NORVAL H. PIERCE thought the definite plan of postgraduate instruction outlined by Dr. Shambaugh was practical and ingenious, as utilizing the possibilities of medicine as it is known in this country, but how is that plan to be carried out? It seemed to him that the whole subject of postgraduate instruction in Chicago is tinctured by our national beliefs. Democracy is of necessity diffuse in its efforts. It lacks definite scope. Dr. Smith may start a postgraduate school, Dr. Brown may start a hospital, and Dr. Green may even start an undergraduate school, all with different purposes and ideals. What we need is coordination and this, he thought, should take place through the university. He did not believe that postgraduate instruction would advance perceptibly if left in the hands of separate interests, but felt that coordination is sure to come. The Illinois Charitable Eye and Ear Infirmary is an example of our democratic incoordination. Dr. Pierce believed the men in that institution are, for the most part, doing the best they can and that they are guided by sane and practical policies, but thought it would never amount to anything as a teaching and research institution as long as it was a little comet circulating in an orbit of its own. It should be under the jurisdiction of the university. The university has authority, it has the administrative ability, and is a cogent body that can and will direct its parts on known idealistic lines. He expressed his great disappointment and sorrow that they had never been able to place the Illinois Charitable Eye and Ear Infirmary under a university administration, because it is used largely for the purposes of personal advancement in operative technic. The assistants come there not in order to help along and forward the general purposes of the institution. They come there to gain experience, and as soon as they are instructed, or as soon as they get as much as they think they can out

of the institution, they either leave or they become disgruntled because they are not made chiefs of service. A course of instruction is now being started for the interns, but without system. In a haphazard way one doctor speaks on something today and somebody else speaks tomorrow—perhaps on the same subject. There is no coordination, no real directing of the students, which should be done by heads of departments or by some controlling body. This university plan would prevent the entrance to the teaching staff of incompetent men, and he considered this a very important function of the university control. Such a plan would stabilize the institution; courses would be outlined and given by heads of departments who would be responsible.

Dr. Pierce believed the only possible way to carry out the plan outlined in Chicago is to put the various eye, ear, nose and throat institutions under university control.

Dr. Pierce did not agree, and did not believe that any teacher would agree, with Dr. Stein in his suggestion that we eliminate instruction of every kind concerning the eye, ear, nose and throat from the undergraduate course. It would be impossible to do so because of the hospital examinations for interns. They ought to know something of these diseases and of the examination of these organs when they go into practice.

As to what the society was going to do to advance its professional interests, in the past the "old wheel horses" have been the ones who carried on the programs, but it is now up to the young men to "carry on," and carry on better than the old ones did. He thought it a deplorable fact that the programs of the medical societies are not much better now than they were twenty years ago. There is a lack of scientific research, too much superficial clinical work, too little individual thought and too little attention to the borderline matters of our specialty. We should all be as much interested in the science of our specialty as in the things that gain us our daily bread. Otherwise we are bound to degenerate. Physiology ought to be just as important as the pathology or the treatment of various kinds of diseases, and if this spirit can be implanted or activated we are sure to advance. If not, if the society is to meet just to hear about the removal of turbinates,

catheterizations of the eustachian tube, or operations in general, the specialty is going to degenerate and will not come up to the standard which Dr. Pierce believed will be set in the very near future.

Dr. J. Holinger said he had been interested in the subject of advancing otology for thirty years. After thorough discussion, three fundamental requirements were put down. First, it is necessary to have a large clinic. The most important cases are rare. Only a large clinic can furnish an adequite number to be worth analyzing. The second requirement is a large and well financed laboratory with sufficient instruments and sufficient space for men to work in. The third important requirement is ample fresh postmortem material so that pathologic material can be secured in the early hours after death has occurred. If the profession is unable to fit out and support such a clinic, the general public should be called upon to help. The public should be educated to the importance of such work. The splendid work done in the Vienna clinic was only possible through the combination of a large clinic, good laboratory facilities and ample fresh material for postmortem examination. In the United States neither Siebenman nor Wittmaack would have had the opportunity of doing the important work that they have given to the profession. In going before the public and interesting them in the fact that these things are necessary to the further advancement of science, we will also interest the public in the things we are trying to do in their interest. They will recognize the difference between really scientific effort and quackery.

Dr. Joseph C. Beck said that in the past twenty years it had been his custom to take men and women into his clinic and train them for a year or more in the work of the clinic. During this time he has trained twenty-three men and women in this way. He realized that this work had some defects and intended to give it up in October, because he felt that what Dr. Shambaugh and the other members of the committee of the American Medical Association had recommended was the best that could be had in this country or anywhere else. In studying abroad he had watched the clinics over there, and if the plan proposed and outlined by Dr. Shambaugh goes through, we will have their method "beat off the earth." The

method that is employed in Europe, especially for Americans, does not compare with this new plan. We have the universities, the laboratory facilities, the large outdoor departments, and all we need is to have the men connected with the university give their time to the work. Plenty of postmortem material can be secured if we can get rid of the crooked undertakers who prevent us from obtaining postmortems. The truth is that the profession is too busy to do the kind of work that Siebenman and many others over there do. There are plenty of men here who have the ability, but they are too busy with other things, not always practice, to do such work.

If the method outlined by Dr. Shambaugh is put into effect, Dr. Beck felt sure that a man can become a very well trained specialist in this country. Dr. Dean of Iowa City has a method of taking only five men at a time, and in that manner of training they can develop better than in any of the European clinics. In Vienna or Berlin they do not train the Americans as they do their own men but train their assistants a great deal as we now propose to do. By taking out the second or third assistant for a night or two of pleasure it is sometimes possible for the American student abroad to get an opportunity to do an operation, but seldom otherwise.

Dr. Beck agreed with Dr. Wilson that the taking of accurate histories is very important and that very few specialists do this. It is also important to follow up the cases as much as possible and make additional notes from time to time.

Another thing in touching upon the future of otolaryngology was that one should keep in better touch with the other branches of medicine. There is not enough reading done of articles dealing with borderline subjects. Dr. Beck called attention to what the Institute of Medicine of New York is doing in an attempt to interest the specialists in allied subjects, by furnishing comprehensive abstracts, such as has never been done before. He urged that the members of the society support this movement so that it would be carried on.

In his clinic at the North Chicago Hospital, in the future Dr. Beck and his associates will do only the "brush up" teaching for the men already trained as otolaryngologists, as outlined by the scheme of the committee of the American Medical Association and particularly by Dr. Shambaugh. Almost

all of the men and women that Dr. Beck has trained in the past have been taken in charge by otolaryngologic friends of his, where they have served for a year or more as assistants and associates before going into practice for themselves.

Dr. Beck thought the facilities for postgraduate work in Chicago were excellent and that it would not be at all impossible to have an abundance of fresh postmortem material from that source also.

Dr. George W. Boot said he was not so much interested in the education of the specialists as in that of the undergraduate. He was sure it was a mistake to say that the undergraduate should not be taught anything about the eye, ear, nose and throat, for a man could not be taught too much about anything. It is a mistake to think that if these things are taught, a man will not refer work to his teacher, for the reverse is the case. The more he knows, the more cases he will recognize as needing the care of a specialist. Rush Medical College requires for graduation 1.2 major hours; Northwestern, 16 hours clinical and 96 hours dispensary work; Loyola, 0.8 of a major for ear, nose and throat work; P. & S. requires 60 hours' clinical and 18 hours5 dispensary work. Dr. Boot believed Northwestern had the best plan of all. If he had his way he would dispense entirely with the didactic work and most of the clinical work. Anything that can be given in didactic work can be learned just as well from a textbook, but he would like to have the students do real work in examining noses and throats, not their own, but those of the dispensary patients.

Dr. Boot agreed with Dr. Pierce that it was a crime the way the Illinois Charitable Eye and Ear Infirmary was managed, but believed this was largely due to the men who managed the place and the heads of the departments. He also thought the way the Cook County Hospital is managed is another crime. There is a constant stream of outdoor clinical material going there—enough material to supply all the classes that go through, but the only class that takes advantage of it is that from Loyola. He tried to get the classes from the College of Physicians and Surgeons to go there but did not succeed.

He believed Dr. Holinger's idea of a large institution

where there could be many patients and abundant apparatus was a good one if it could be put into practice, but the obvious place for this is at the Eye and Ear Infirmary.

As to the necessity for accuracy of diagnosis brought out by Dr. Wilson, he heartily agreed. He had very unsatisfactory experiences along this line in hunting up histories of cases indexed as brain abscess at the County Hospital a year ago. Many of the histories were dictated by very capable men but were very incomplete, in many instances no statement as to location of the abscess being given.

Dr. Boot hoped that a different type of undergraduate teaching would be available in Chicago in the near future, and felt sure that if this could be brought about the future of otolaryngology would be much brighter.

DR. SHAMBAUGH (closing) expressed himself as much pleased with the discussion. The subject had many angles which cannot be touched upon in a short discussion. A great mistake was being made in many places by allowing interns in general medicine to acquire the technic of nose and throat operations. These men had no opportunity of learning how to recognize the proper indications for such operations, and when they go out into practice one heard on all sides of the indiscriminate slaughter of the tonsils as well as of the turbinal bodies and operations upon the septum.

Dr. Shambaugh stated that in the outpatient department at Rush Medical College, he has for several years been carrying out a plan similar to that which the report of the American Medical Association outlined, for providing training in otolaryngology. He has had a motto framed and hung in the outpatient department which reads as follows:

> "Three essentials for the successful practice of otolaryngology, in order of their importance:
>
> 1. Proper respect for the patient and interest in his welfare.
>
> 2. Ability to make diagnoses and to recognize the proper indications for surgical interference.
>
> 3. Skill in operative technique."

He insists that this relationship must always be kept in mind in providing instruction for those preparing to take up this work.

THE CHICAGO LARYNGOLOGICAL AND OTOLOGICAL SOCIETY.

Meeting of Monday Evening, October 3, 1921.

THE PRESIDENT, DR. ROBERT SONNENSCHEIN, PRESIDING.

DR. I. PILOT (by invitation) addressed the society on

"Histopathology and Bacteriology of the Adenoid."

(ABSTRACT.)

The adenoids have been discussed for many years with reference to their hypertrophy and resulting obstructive symptoms and to their rôle as a portal of entry in tuberculosis. One phase entirely neglected has been the bacteriology. While many investigations of the bacterial flora of the nasopharynx with special reference to the carrier problem have been made, such work was carried out with cultures obtained with a swab which can at best touch the surface of the vegetations. To obtain more accurate knowledge of the incidence and numbers of the more common organisms and to ascertain the extent to which these organisms flourish in the recesses of the nasopharynx, a study was undertaken by Dr. S. J. Pearlman and Dr. Pilot of the extirpated adenoids. Histologic studies were made to bring out the cellular changes, if any, to the presence of the bacteria and to correlate any particular pathologic condition with the character of the bacterial flora.

The excised adenoids obtained from children 5 to 16 years of age consisted of lymphoid tissue made up of several folds and frequently revealed cryptlike depressions like the tonsils. Cultures were made upon blood agar and Loeffler's serum from the surface and from the depths of the clefts and crypts.

Every adenoid gave positive growth. The cultures from each adenoid revealed several organisms, regardless of the size or structure of the vegetation, occasionally one organism predominating; rarely, however, in pure culture. The incidence of the various bacteria found is indicated in the following table:

Organism	Number of individuals	Per cent positive
Streptococcus hemolyticus	103	61
Streptococcus viridans	103	89
Pneumococcus	103	65
Type 2	103	2
Type 3	103	10.3
Type 4	103	52.7
Mathers coccus	103	17
Staphylococcus	103	60
Gram negative cocci	103	79
B. influenzæ (Pfeiffer)	115	40.9
B. diphtheriæ	100	12
Diphtheroids	100	30
B. mucosus capsulatus	103	14
B. fusiformis	10	20

The flora of the nasopharynx as revealed by cultures with a swab was compared to the flora of the surface and depths of the adenoids. The hemolytic streptococcus was found in 40 per cent of 25 persons in the cultures from the swabs, while the excised adenoids yielded larger numbers in 60 per cent of the same individuals. The greatest incidence and numbers of bacteria occurred in the depths between the folds and in the crypts of the vegetations, lesser numbers on the surface epithelium and least upon the swabs of the adenoids in situ.

The excised faucial tonsils of the same individuals were similarly compared and found to be somewhat different in their flora. Hemolytic streptococci occurred in 95 per cent, B. influenza in 53.9 per cent, B. diphtheria in 12 per cent, and diphtheroids in 17 per cent The flora of the nasopharynx was further investigated in children whose adenoids and tonsils were removed and compared to a similar group in which the adenoids and tonsils were present. In the tonsillectomized, hemolytic streptococci occurred in 40 per cent, B. influenza in 26.5 per cent, pneumococci in 32.5 per cent. In the nontonsillectomized, hemolytic streptococci were found in 56.3 per cent, B. influenza in 39.3 per cent, and pneumococci in 32.5 per cent. The number of all of these bacteria was decidedly fewer in the tonsillectomized children.

Histologic sections were made from the adenoids which had been studied bacteriologically. No striking pathologic changes could be ascribed to any flora or organism. The adenoids with deeper folds and many crypts, particularly those containing amorphous and cellular debris, as a rule, harbored large numbers of bacteria, especially hemolytic streptococci. For the most part histologically the specimens were uniform in their appearance, regardless of the character of the flora. Every adenoid presented evidences of chronic inflammatory changes no greater in degree than the changes that are constantly present in the lymphoid tissues in close proximity to the mucous membranes of the normal individual. In none were found acute cellular reactions to the presence of the organisms that lie in close contact with the vegetations.

From these studies it is well to recognize that the nasopharyngeal vegetations should be regarded not only as hyperplastic obstructive masses but also as foci like the tonsils where dangerous bacteria are lodged. This conception is to be borne in mind in connection with the treatment of diphtheria carriers where the removal of the adenoids as well as the tonsils frequently terminates the carrier state. In the treatment of the metastatic infections, such as endocarditis and arthritis, the adenoids should be regarded as possible foci of infection. Although probably not as important in this respect as the faucial tonsils, the adenoids are to be looked upon as a portal of entry of many acute and chronic diseases.

DR. SAMUEL SALINGER read a paper entitled

***"Acute Lacunar Adenoiditis."**

*See page 220.

DISCUSSION.

DR. D. J. DAVIS said a few words regarding the ideas and principles underlying the data presented.

Two parts of the gastrointestinal canal are of interest in connection with infections. Passing downward from the mouth to the rectum, if one makes cultures at frequent intervals, one will find two regions with maximum numbers of bacteria. There will be relatively a small number of bacteria at the lips and, passing down, they will increase very greatly, so that there will be found a maximum in the nasopharynx. In

the region of the esophagus they decrease rapidly, and in the stomach there are relatively few bacteria. On passing down into the gastrointestinal canal, the numbers gradually rise, another maximum being attained in the region of the ileocecal valve and upper colon. From here the number of bacteria again diminish toward the rectum. This is also true as regards the incidence of pathogenic organisms and infections. Infections are very common in the nasopharynx region, then they are relatively uncommon until the lower part of the small bowel, and especially the region of the appendix, is reached, where again many infections appear.

We may parallel this incidence of bacteria and infections if we consider the amount of lymphatic tissue along the gastrointestinal canal, the maximum appearing in the pharyngeal region, then diminishing in the esophagus and stomach and again gradually increasing in the intestine in the region of the ileocecal valve. As to the meaning of this, Dr. Davis thought the body had developed this lymphatic mechanism in order to protect itself against the bacteria which live in these localities. The lymphatic mechanism presumably is a defensive one. Wherever it is found in the body it appears to be of use for protective purposes. The distribution of lymphatic tissue, for example, in the hilum of the lung, in the mesentery, in the groin, etc., would lead one to suggest that it is protective, and presumably that is the purpose of this tissue as it appears in tonsils and adenoids and in the gastrointestinal canal.

On the other hand, while the body has developed this lymphatic mechanism to protect itself, the bacteria are equally adaptive and have altered themselves in such a way as to attack the very mechanism the body has developed to protect itself. Streptococci, apparently by preference, frequently attack lymphatic tissues in the throat. The typhoid bacillus in the bowel evidently does the same.

Dr. Davis called attention to a peculiarity of the lymphatic tissue in the submucosa of the gastrointestinal canal. It has efferent channels but no afferent channels. It is located just beneath the mucosa, where it can readily absorb material and there is no need of afferent channels. There seems to be no question about the function of these lymphatics. Bacteria can

practically always be found in the centers of these glands in the normal state. A few bacteria no doubt occasionally get through into the deeper lymphatics and thence into the circulation, where they usually die, but at times may cause infection.

The speaker considered the carrier question of importance in connection with the data presented by Dr. Pilot. The adenoids are of great importance in this regard, and one should always think of this location as a place where certain dangerous bacteria may reside for long periods of time.

As this study has progressed, they have come to realize that many parts of the body have developed their own flora. And as they investigate this point more in detail, they find that even very limited localities have their own individual bacteria. The bacteriology of the surface of the tonsils and of the crypts is very different, and the bacteriology of the adenoid may be quite different from that of the tonsil, or the pharynx, or the larynx.

Dr. Davis felt that much work is still to be done. Studies of this sort have just begun. For example, little is known of the anaerobic flora of the respiratory tract, and especially of the tonsils. He cited the fact also in this connection that it was not known until very recently that the influenza bacillus is one of the very common organisms of the respiratory passages, present often in individuals normally as well as in those suffering with various kinds of infections. It was largely because of the lack of knowledge of its distribution that it was so long thought to be the cause of influenza epidemics.

Because of the fact that new methods are being devised constantly, it is necessary to revise bacteriologic data frequently. This necessitates more or less constant reinvestigation. However, this work of Dr. Pilot's on the adenoid appears to be the first systematic study of the bacteriology of this organ ever made.

Dr. George W. Boot was impressed with the large percentage of patients who had tonsils and adenoids removed and still gave cultures of the same organism as when the tonsils and adenoids were present. This doubtless explains why in so many cases when the tonsils and adenoids are removed there still remains an enlargement of the lymphoid islands in the pharynx, which sometimes becomes very annoying.

Dr. Salinger called attention to the fact that his patient had enlargement of the postcervical glands. Dr. Boot thought this rather peculiar, as his idea of the lymphatic glands was that the adenoids drained into the same set of glands as the tonsil. He asked if anyone else had noticed the drainage into the postcervical glands.

Dr. John Edwin Rhodes said that this field of investigation was not available when he was a student, and he was much gratified to hear such a paper as that of Dr. Pilot. He considered the society was very fortunate in having such a paper presented, showing the painstaking work of the essayist in connection with the study. He felt that the profession should avail themselves of all such things in an effort to trace down the bacteriology of disease, and with the laboratory facilities of this time that was possible for every practitioner. He had been much edified and benefited by the papers.

Dr. J. Holinger wondered why if the diphtheria bacilli were in the crypts and folds of the adenoids they did not make trouble more frequently. The statement had been made that the children whose adenoids had been examined had no fever, no sign of acute inflammation and no local or general indications of the presence of these bacilli. No streptococcus hemolyticus or any of the virulent organisms had made any symptoms. He asked if there was any possibility of explaining these facts, or did the profession have to go back to the old expression of "genius epidemicus," which had meant much many years ago but which they thought they were rid of.

Dr. Harry W. Woodruff, Joliet, said he would not attempt to discuss the subject from the standpoint of bacteriology but was interested in the point made in the examination of adenoids in children. He had always felt that using the finger in the examination for adenoids was almost as severe and difficult as removal of the adenoids, and he had used the method suggested by Dr. Salinger for several years.

Dr. Alfred Lewy thought that very few realized the amount of intelligent industry necessary to get together the mass of data presented by Dr. Pilot, and expressed great interest in Dr. Davis' analysis of the work, especially in his observation that bacterial flora are most abundant where lymphatic tissue is, and the fact that infection occurs most frequently in those

localities. He asked Dr. Davis (realizing that it was a philosophic rather than a practical question) whether it would not be as well to say that the infection was more frequently manifested in those points, and whether or not recent investigations had thrown any light on the cause of such apparent localization. He thought that as specialists we were likely to center our attention too closely on local conditions and not examine sufficiently into the general condition and environment of the patient for causes of nonresistance to infection.

Regarding Dr. Salinger's paper, referring particularly to acute infections of the nasopharynx, he thought it was rarely necessary to subject the patient during such acute conditions to attempts at posterior rhinoscopy, as he believed nearly every case of tonsillitis was associated with nasopharyngitis, either location being primarily inflamed. Ordinary sore throats are commonly nasopharyngitis, as indicated by the inflammation along the salpingopharyngeal folds. In his opinion chronic nasopharyngitis is the most common inflammation found in the upper respiratory tract.

Major Sherman, M. C., U. S. A. (Camp Sam Houston, Texas), felt that the society was doing wonderful work and expressed his personal thanks for being allowed to attend the meetings. During the last year Major Sherman had been impressed with the large number of adenoids found in men in the army. There are now more boys of eighteen and nineteen than before the war, and the number of adenoid cases is large. The question of examining these cases naturally needs consideration as to why the patients have the same infection after the adenoids are removed. He had found some form of nasopharyngoscope which allowed a full view of the adenoid mass and had found no difficulty in using this, even in very young children. By this method it was not difficult to find exactly where the masses were. In his opinion, the reason there was recurrence was because all of the mass was not removed. It was interesting to see how many times when an adenoid was removed, a small walled off abscess was found within the mass.

Dr. A. A. Hayden emphasized what Major Sherman said concerning the use of the nasopharyngoscope in looking for adenoid masses, either after or before the operation. This

could be done almost without pain, and an excellent view of the entire region could always be obtained. He felt that everyone used the finger very frequently, because it was a convenient thing to do, but this was open to the very valid objection of alienating the affections of one's patients.

Dr. Thomas Faith said that when Dr. Salinger spoke of disseminating this knowledge to the practitioners in general, he felt one point might be added, namely, that these acute adenoid attacks explain many of the febrile attacks very young children often have. While this is recognized by laryngologists it is very frequently not recognized by practitioners in general. He believed that many of the socalled attacks of gastrointestinal disturbance in children could be explained as attacks of adenoiditis.

Dr. Faith believed that in disseminating the knowledge of the presence of adenoids in adults, the knowledge ot the acute attacks occurring in children might accompany it to advantage.

Dr. Harry Pollock called attention to the fact that some years ago one of the members read a paper on tuberculosis of the adenoids, and he was surprised that Dr. Pilot had not mentioned finding any tuberculosis in the 115 cases examined. This condition was quite common, especially in the presence of enlarged glands.

In regard to Dr. Holinger's question as to why the children with these large, diphtheria infected adenoids showed no symptoms—in examining school children Dr. Pollock had found as high as 15 to 25 per cent of the cultures sent to the Health Department showed diphtheria carriers, but the children were perfectly healthy. At that time they were not doing the Schick test, and he asked the Doctor what relation the diphtheria carriers now had to the Schick test. Recently there had been quite an epidemic of Vincent's angina. Dr. Pilot mentioned finding the fusiform bacillus, but said nothing about the spirilliform, and Dr. Pollock was surprised that he had not mentioned finding this in the tonsils and adenoids.

The speaker felt that the best way to locate large adenoids in adults was by means of the nasopharyngoscope, but children who had their tonsils and adenoids removed will not hold still and permit this, so it is usually necessary to make a digital examination. In adults in a few cases where adenoids were

suspected, where the tonsils and adenoids had been removed but patients complained of discharge of mucus, one must think of Thorwaldt's disease, which could be mistaken for adenoiditis. They had recently had two cases in which they found Thorwaldt's disease, and after opening the bursa the patients got well. One patient, the daughter of a prominent surgeon, had large cervical glands. She had the tonsils enucleated, but the glands kept on growing and were diagnosed as tubercular glands. There was no trouble in breathing, but on examining with the nasopharyngoscope they found large masses of adenoid tissue. These were removed and the glands gradually disappeared. Their experience was that the posterior cervical glands would usually enlarge from the adenoids. In his opinion the adenoids drain through the posterior cervical glands and the tonsils through the anterior.

Dr. Pollock wished to know whether the children in whom the diphtheria bacillus was found gave a positive reaction to the Schick test.

Dr. E. P. Norcross said that he saw many children with acute conditions where the site of the trouble was in the postnasal space. In many of these cases the tonsils were not inflamed, the only evidence of a throat infection being a red pharynx and postnasal discharge. He believes that the adenoid is very often the site of acute inflammation in children.

Dr. I. Pilot (closing the discussion on his paper) said that the incidence of the organisms in tonsillectomized patients was frequent, but one should remember that there was considerable adenoid tissue still present in the nasopharynx, all of which was pitted, and these follicles continued to harbor various bacteria in children who have had their tonsils and adenoids removed.

Regarding the question of diphtheria carriers, the number of positive cutlures obtained was 12 per cent of 100 children, and it was indicated that of the 12 strains only two proved to be virulent. In an extensive study made at Johns Hopkins Hospital by Guthrie, Gelien and Moss similar results were obtained, in which positive results were present in anywhere from 10 to 18 per cent of children. There, too, the strains were tested for virulence, and only about 11 per cent were found to be virulent, so the actual number of diphtheria car-

riers could be narrowed down to those carrying virulent diphtheria bacilli. Their data seemed to indicate that the carriers of avirulent bacilli were harmless and should not be treated as dangerous unless the cultures were tested for virulence.

Organisms of the streptococcus hemolyticus group, B. influenzæ and others that were quite virulent could exist in the nasopharynx without causing any symptoms on the part of the person, depending upon the resistance of the individual and also upon the invasive properties of the organisms. The organism might be virulent, but its power of invading the body was another property, which must be considered in determining the actual danger of the organism. The more invasive type of streptococcus hemolyticus due to infected milk from sore throat are organisms which are a little different in their reactions and have chiefly this invasive property. An individual infected by this particular strain is dangerous to another individual, while an individual carrying the ordinary streptococcus hemolyticus, which does not have this particular invasive property, is not dangerous.

Dr. Pilot had made no attempt to present any complete histopathology or bacteriology. The demonstration of evidence of either active or latent tuberculosis with strains of tubercle bacillus in the tissues constitutes a big problem in itself. Each of the organisms was studied and considered as a separate problem and no reference to the tubercle bacillus and other organisms was made because the bacteriologic study is not yet complete. The fusiform bacilli encountered were those found in anerobic cultures of ten specimens. The spirillum was encountered in connection with the fusiform bacillus, but nowhere as frequent as in the tonsil. The adenoids are not as favorable for the formation of masses of fusiform bacilli and spirilla.

He had come across an interesting specimen which had ideal conditions for the possible formation of such an abscess as was mentioned by Dr. Pollock—that is, the fusion of two clefts with a canal underneath the union, but in that instance there was no abscess in connection with the canal formation.

Dr. Samuel Salinger (closing the discussion on his paper) stated that the scope of his paper did not include the catarrhal form of nasopharyngitis which is associated with common

colds in children. He wished to call attention only to the particular form of acute lacunar adenoiditis, and did not expect to touch upon the other types of adenoid infection, which is a large field and which would include Thorwaldt's disease, the later having no connection whatever with the acute type he considered.

As to the use of the nasopharyngoscope, if one is called to attend an acute condition in a patient's home, he is not likely to have the pharyngoscope with him. Secondly, in the presence of a large mass of mucopurulent material there is much difficulty in getting a good view. With the nasopharyngoscope one can get an excellent view of a limited area but not a general ensemble, and while the nasopharyngoscope has its place in some conditions, Dr. Salinger thought it was better if one could see the condition as it exists without the aid of mirrors or magnifying glasses, and in its relationship to the surrounding structures.

In regard to the enlargement of the posterior cervical glands he found this was very frequently mentioned in connection with inflammation of the adenoid. Many authorities consider this finding to be particularly pathognomonic of infections in the nasopharynx.

Dr. Robert Sonnenschein asked Dr. Davis if he did not think Dr. Salinger was correct in using the term "lacunar" instead of "follicular." Would not the same nomenclature be applied to the adenoid as to the tonsil? The actual "follicles" of the tonsil are lymphoid masses lying beneath the mucosa. Ordinarily when the term "follicular tonsillitis" is employed, it refers to infection of the crypts or lacunæ of the tonsil, hence the expression "follicular" is really a misnomer in these instances.

Dr. Davis, replying to the questions, thought the point of Dr. Sonnenschein was well taken. The follicles as they are seen in sections often show necrotic tissue and various inflammatory cells, and seem to be the part of the organ which exhibits the greatest degree of change.

Regarding the manifestation of disease, brought out by Dr. Lewy, the speaker thought one should consider "disease" as a relative term. He did not suppose anyone was really normal or absolutely free from some pathology. Bacteria are con-

stantly passing into our interior, and we are constantly absorbing toxins, particularly through the gastrointestinal canal. This is evidenced by the fact that in the normal newborn child there are practically no plasma cells anywhere in the body, even in the tonsil or in the appendix. They do not appear until several days after birth when bacteria become prevalent in the tract. As the bacteria and toxins are absorbed the body defends itself in one way by inflammatory cells. In saying that many infections appear in the region of the ileocecal valve and in the region of the oropharynx he meant that the chief manifestations of disease appear in these two localities.

With reference to the diphtheria carriers, Dr. Davis believed the extirpation of the palatine tonsils would diminish the number of bacteria carriers but did not think it would do more than that. It might or might not cure a carrier, but would probably reduce the number of germs present.

JOINT MEETING OF THE CHICAGO MEDICAL AND CHICAGO LARYNGOLOGICAL AND OTOLOGICAL SOCIETIES.

A joint meeting of the Chicago Medical and Chicago Laryngological and Otological Societies was held on Wednesday evening, November 9, 1921, with Dr. Robert Sonnenschein, President of the Chicago Laryngological and Otological Society, in the chair.

DR. M. A. GOLDSTEIN, St. Louis (by invitation), addressed the society on

"Problems of the Deaf."

ABSTRACT.

Not only the general medical profession but even otologists throughout the country know very little about the work that is being done in conjunction with the education of the deaf children. Chicago is peculiarly fortunate in its relation to the deaf child. It is the first city west of the Alleghanies that developed oral training for deaf children.

There are two methods of oral training of the deaf child, one of which is by sign language, in which signs, instead of speech, are used, and the other method is to teach children who have never heard the sounds of the human voice speech, even though it is artificially produced, and lip reading, so that they can come in contact with the rest of speaking humanity. The deaf child can be taught to speak and to come in contact with people by lip reading, a method which is used both for the child and the adult where hearing has been either congenitally or adventitiously lost.

The public school system of Chicago has since 1896 shown the possibilities of oral training and speech training for deaf children instead of the sign language. Much of this good work has been brought about by the conjoint request of the parents of deaf children and of boards of education who feel that deaf children should have such opportunities as are offered normal children, in order that they may grow up to manhood and womanhood. It has been a long and hard struggle for the few who have interested themselves in these prob-

lems to actually convince other members in the profession that the opportunities for deaf children are great. Splendid progressive work throughout the country is being done, and otologists should help to shoulder the responsibilities which tend toward the development of deaf children. It is by the cooperation of the medical profession, and particularly the otologic and laryngologic members of the profession, that improvement in the education and development of methods for deaf children can be brought about. The sky has been cloudy for one-quarter of a century, but the dawn is coming, and there are specialists throughout the country who are beginning to show more than a passing interest in these problems of deaf children. There is a responsibility that medical men and otologists owe to deaf children, and the deaf child is as much entitled to a share of consideration as is the blind child, the normal child or the crippled child. Every child born deaf, who is not subnormal and has no mental defects, should be given the opportunity of being taught like normal children. Every congenitally deaf child can be taught fluent speech, as has been proven in all large metropolitan centers of the country. Deaf children, who have had six or seven years of training in their respective schools, are going to high schools and are sitting in the classroom with normal children and carrying on their work. For instance, there are three or four deaf children in Chicago who are doing that, one of whom is the scholarship pupil in his class. He is getting his lessons by lip reading. This is the opportunity the teacher and the otologist is creating for the deaf child in the future. The time is coming when teaching methods will become more perfected, when imperfections in speech will be corrected. Not all deaf children speak distinctly, nor do all doctors speak distinctly, but this should not be taken as a criterion.

Through the courtesies of the teachers of the several schools for the education of the deaf in Chicago, and to show what progress is being made and what is being done in actual practical work in the schoolroom, Dr. Goldstein called the classes one by one and had the teachers demonstrate what the deaf children could do by lip reading and other methods of oral training. There were classes representing the Parker Practice School, the Beidler School, and the Alexander Graham Bell

School. Demonstrations were given by the children through their teachers. Miss Plumb of the Parker Practice School and her pupils gave a demonstration of the first signs of speech. When Miss Plumb spoke the words thumb, shoe, eye, elbow, nose, etc., the pupils pointed respectively to their thumbs, shoes, eyes, elbows and noses. She then showed the first elements in speech by lighting a candle and having the children blow it out by uttering the sounds P, O, sh, T, wh, and ah.

Dr. Goldstein said that musical instruments are used, besides the voice, in training children to learn rhythm, accent, and to appreciate pitch. In some schools this is being developed to a considerable degree. Demonstrations of rhythm work were given by Miss Smith of the Parker Practice School with her pupils, with Miss Jones at the piano. Music is used not only for rhythm but to educate tactile sense.

Miss Knox of the Alexander Graham Bell School gave demonstrations of what the pupils in the hard of hearing class could do by lip reading.

Miss Golden of the Beidler School, with her pupils, gave demonstrations in lip reading, and Miss Taylor of the Parker Practice School gave a demonstration of what her pupils could do in arithmetic by lip reading. These demonstrations showed that every congenitally deaf child can be trained to speak and can be trained to lip read to such a degree as to become a useful member of the community in which he or she lives.

DR. GEORGE E. SHAMBAUGH read a paper entitled

***"Problems of the Hard of Hearing and the Use of Electric Hearing Devices."**

*See page 225.

MISS VALERIA D. MCDERMOTT, executive secretary of the Chicago League for the Hard of Hearing, read a paper entitled

"Community Organization for the Deafened."

ABSTRACT.

The work of the league begins at the place where that of the otologist ends. Its primary purpose is to ameliorate the condition of the deafened. And what is the condition of the

deafened? This question can best be answered by giving a typical illustration:

With all hopes of cure removed, unable to enjoy or take part in family or friendly conversations or hear a concert, lecture, theater or church service, or earn a livelihood in a profession or occupation in which they have spent years of preparation or service, they come to the league. A hopeless condition, it would seem. But it is not, for the league has yet to encounter a case that it could not help. In many instances it has transformed discouraged, listless, purposeless, unproductive individuals into happy, self supporting members of the community.

How is this accomplished? Not by an experiment, but by an organization and a plan worked out by those who had a psychologic and sympathetic understanding of the problems of deafness—the deafened themselves. In this respect it differs from all other organizations working with handicapped groups and also explains its success as a growing and spreading movement, for there are now twenty-two cities with like organizations doing a similar work for the hard of hearing.

The first assistance given to those who come to the league is to offer a substitute for their impaired or lost faculty, sight for hearing—teaching them to read the lips. Then, unconsciously, through association with others who have met the same handicap and overcome it, confidence is inspired and self pity vanishes.

There are many things that persons with defective hearing can do. There are vocations and professions just as interesting as those that have to be abandoned. This is the psychologic attitude that the league creates in relation to employment, and gradually those who have in their own minds despaired of being able to earn a living become interested, begin to inquire, want to retrain or will try the position advised.

From April 1, 1920, to March 31, 1921, 6,979 persons came to the league; 2,661 men and women attended the lip reading classes; 1,382 lessons were given to twelve ex-service men sent to the league by the Federal Board for Vocational Education. A lip reading class for adults was established in the Lowell School, Oak Park, Ill. Three scholarships in lip read-

ing were awarded, one to a shut-in girl and two to young women employed.

Employment was found for applicants in the following lines of work: Housework, typing, bookkeeping, filing, billing, addressing, cashier, commercial art, press clipping, accessioning, assembling, printing, proofreading and gardening. A study of professions and occupations that the hard of hearing can follow was begun and is being continued. Vocational counsel was given, and as a result a number of persons are pursuing courses of study. Three ex-service men are receiving training in industrial chemistry, mechanical dentistry and cabinet making. Two women finished courses and were placed in positions in the filing department. One man is taking a course in watchmaking, and two women, a teacher and a trained nurse, were advised to pursue courses, one in arts and crafts, and the other in microscopic analysis. These two women were given scholarship loans by the league, making it possible for them to take the training advised.

This year the league plans to project its activities into the community, becoming more a public institution and less a private agency. The establishment of a community house for the deafened similar to those already established in Philadelphia, Boston, Toledo and San Francisco is now under consideration. The employment service of the league is to be extended, for herein organizations for the hard of hearing can render the greatest assistance. The third feature of the program takes the league into the field of prevention—the establishment and maintenance by the league, in cooperation with the Chicago Department of Health, of an ear clinic in the public schools.

It is just as important, and possibly more so, that the children's ears receive proper examination and treatment, as their eyes or teeth, although there is only one city in the United States—Rochester, with its eminent Dr. Franklin W. Bock—that has gone into this field and done a large and constructive work. The matter of establishing a clinic is now before the executive committee, and the details are not entirely worked out, so that it can only be referred to at this time as a possibility for greater service, and a measure taken for the prevention of deafness in early life.

DISCUSSION.

MISS MARY MCCOWAN, teacher of the deaf in Chicago, stated that 38 years ago she came to this city and established a small experimental school for teaching the deaf. In those days, when they spoke about music and rhythm for deaf children, they were laughed at, and when they talked about speech for deaf children they were considered impostors. She rejoiced to have lived to see the day when it was an accepted fact that deaf children could be taught to speak, and it was our duty to see that they were taught to speak.

DR. FRANK G. BRUNNER, Director of Special Education, Public Schools of Chicago, said the teachers of this city would welcome any suggestions from members of the medical profession in reference to better methods of teaching the deaf. He said we were just at the threshold in the teaching of the deaf, and phenomenal progress might be expected in the future in comparison with what had already been done. Any amount of time was worth spending if we could put children in possession of speech and make it possible for them to associate and converse with normal individuals in the community. His experience had been that physicians, and sometimes even otologists, did not seem to appreciate the necessity of getting deaf children into schools for the deaf at an early age. Physicians not infrequently kept these children out of a school for the deaf until they had begun to lose their speech or until their speech had become so imperfect that the teacher had to spend considerable time in correcting bad habits of speech before beginning to develop anything like intelligible speech. It is not necessary, as some had supposed, to consult politicians in order to get such children into schools for the deaf. Deaf children are admitted to the schools for the deaf when four years of age, but he did not think it was wise to admit them younger than this.

MISS GERTRUDE TORREY, principal of the Chicago School of Lip Reading, said the members of the society had seen an excellent demonstration of what children could accomplish with lip reading. A great many people become deaf after reaching adult age, and they need lip reading as much as the children. Probably all doctors who recommended lip reading thought it

was only the young people who needed this education, but most important of all was the change of attitude of mind which came from lip reading, and all doctors ought to think of this in recommending lip reading, not only to people who were deaf but to those who were becoming deaf. Almost all people who were a little deaf were in a despondent frame of mind and thought there was nothing ahead of them. When such people took up lip reading they felt more hopeful. After seeing what other people could accomplish by lip reading, gradually they came to realize that they themselves could become very good lip readers.

DR. NORVAL H. PIERCE stated that not long since, he examined the inmates of a large deaf and dumb asylum and found that at least 10 per cent of those he examined could hear more or less, and yet those children were living a life of silence and most of them communicating with one another by means of the sign language. Strange as it might seem, these children were admitted to this institution without the slightest scientific examination.

In looking over the application blanks admitting these children, the cause of deafness and the kind of deafness were filled in by the parents, so that it was not an unusual thing to read that the deafness was ascribed to causes which might provoke a smile if the matter were not so tragic.

State institutions should keep in close touch with well informed otologists, and while it was true that otologists had not been as much interested as they might have been in this subject of training and education of the deaf, he was inclined to think that teachers of the deaf had not been quite as much interested in otologists as they might have been. There was no doubt that these two component parts had in this country developed along separate lines. This could not be said of Germany, where a great advance in the education of the deaf by the oral method had been made, the work being furthered by professional otologists. He believed it would be a good thing if from this meeting a closer communion could be established between otologists and teachers of the deaf.

He wondered if all of the children who had given demonstrations tonight had been thoroughly examined by competent otologists. If they had not been, the system of education

might be materially improved by the cooperation of otologists and teachers of the deaf.

Dr. Joseph C. Beck said that one of the greatest accomplishments in connection with Dr. Goldstein's work with deaf children was to make teachers in his institution who could carry on the work. It was such splendid demonstrations as Dr. Goldstein had given that stimulated otologists to become more and more enthusiastic to do better work. One difficulty lay in not being able to teach deaf children privately, as was required by some parents, particularly the better class of children, who in addition to attending a school for the deaf wanted private tutors. It had been difficult at times for the teachers to devote the necessary amount of time to give these children private instruction.

In regard to the humming, buzzing devices referred to by Dr. Shambaugh, the speaker called attention to a device known as Rice's oscillator, which was supposed to greatly aid the deafened. No differentiation of cases was made, but this oscillator was used in all kinds of cases. In cases in which a diagnosis of fixation of the stapes was made, he was anxious to see if these people could be made to hear again with this oscillator.

In the East at the present time there was a great deal of discussion going on with regard to the use of the X-ray in the treatment of deaf individuals.

Dr. Elmer L. Kenyon stated that in a certain school in Chicago, largely attended, there had been up to within a few weeks a brother and sister attending, aged 13 and 15 years respectively, whose hearing was so impaired they could not possibly hear what was going on in the classroom, and yet had been attending this school (not a public school) year after year. These children should have been properly educated in deaf schools. Why they should have been continued year after year in a school for normal children, accomplishing practically nothing in the way of their own education, he could not understand. Nothing could point with more emphasis to the need of adequate medical inspection in the schools than such serious mishandling of deaf children.

Dr. Kenyon cited the case of a man, 24 years of age, who could not talk understandingly, could not hear well, could not

read and who seemingly lacked in normality of intellect. Examination showed that he could hear loud talking on contact with the ear. His mind was normal, considering the handicaps he had gone through. He could not read more than perhaps every tenth word in a child's book. He had been deafened when he was a child and had had practically nothing done for him. Finding the public school almost useless, he had, after three years of attendance, been taken out, and afterwards had simply been allowed to drift, uneducated, into manhood. Meetings like the present, spreading knowledge of such problems, should eliminate such tragedies.

DR. M. A. GOLDSTEIN, St. Louis, in closing the discussion, said it required a tremendous amount of patience, forbearance, originality and individuality on the part of the teacher of the deaf child. There was no better work being done for the deaf in any of our metropolitan cities than in Chicago. If otologists, friends of the deaf, and representatives of the League for the Hard of Hearing fully realized what this kind of training would do, he believed Chicago would be in the vanguard of this work for many, many years.